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NATIONAL DAM SAFETY PROGRAM. FARRINGTON DAM (NJ00383), RARITAN --ETC(U)

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RARITAN RIVER BASIN

LAWRENCE BROOK, MIDDLESEX COUNTY

NEW JERSEY

FARRINGTON DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

NJ 00383

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

JULY 1978

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Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

NAPEN-D

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

31 AUG 1978

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Farrington Dam in Middlesex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given on the first three pages of the report.

Based on visual inspection, available records, calculations and past operational performance, Farrington Dam is judged to be in a deteriorated condition. The dam's spillway is considered seriously inadequate since 23 percent of the Probable Maximum Flood (PMF) would overtop the dam. To insure adequacy of the structure, the following actions, as a minimum are recommended:

a. Engineering investigations and studies should be made by a qualified, professional consultant engaged by the owner to ascertain the dam's stability and structural adequacy within twelve months from the date of approval of this report. Also, the spillway's adequacy should be determined by more sophisticated methods and procedures at the same time. Any remedial measures necessary to insure the dam's structural adequacy and stability and to increase the spillway's capacity, resulting from these investigations and studies, should be initiated in calendar year 1979. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation or spillway discharge, around-the-clock surveillance should be provided.

b. The dam's mid and low level outlet gates should be restored to full operational use within six months from the date of approval of this report.

NAPEN-D
Honorable Brendan T. Byrne

c. The channel, downstream of the dam, should be cleared of heavy vegetation and the channel improved to provide a better transition to the natural channel of Lawrence Brook. This work should be completed within twelve months from the date of approval of this report.

d. Monitoring of seepage along right abutment and determination of its source and path to the point of visible leakage should be initiated within three months from the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Frank Thompson, Jr. of the Fourth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Cy furn:
Mr. Dirk C. Hofman, P.E.
Department of Environmental Protection

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

Based on visual inspection, available records, calculations and past operational performance, Farrington Dam is judged to be in a deteriorated condition. The dam's spillway is considered seriously inadequate since 23 percent of the Probable Maximum Flood (PMF) would overtop the dam. To insure adequacy of the structure, the following actions, as a minimum are recommended:

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APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: ____________________

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Farrington Dam, I.D. NJ 00383
Sate Located:	New Jersey
County Located:	Middlesex
Stream:	Lawrence Brook
Date of Inspection:	May 4 and 8, 1978

Assessment of General Condition of Dam with Respect to Safety and Recommended Action with Degree of Urgency

Farrington Dam is in a deteriorated condition, exhibiting severely eroded concrete at the crest and downstream face. The dam's low level and high level outlets are not functional and the downstream spillway channel is narrow in width and heavily vegetated. The spillway design flood was determined on the basis of current Corps of Engineers screening criteria and the actual design capacity should be verified by the Owner using more precise and sophisticated methods and procedures. The spillway is capable of passing only 22 percent of the PMF without overtopping the dam. Significant seepage is visible on the right abutment and high uplift pressures at the toe were visible. The original stability analyses were conducted, apparently, without consideration of uplift pressures on the base plane. It is felt that the dam cannot meet current stability criteria for the existing service conditions; this would be further aggravated for the higher pools caused by the PMF conditions.

The available engineering data is of questionable value and is inadequate. A data acquisition program is recommended to be completed within twelve months to include all items listed in Section 7.1 - b. Following acquisition of basic data, formulation of a plan to increase the spillway capacity should be carried within an additional six-month period.

The rehabilitation of the deteriorated dam spillway crest and facing would be part of such a plan. The low and high level outlet gates should be brought up to full operational capacity within six months.

A warning system should be established to the downstream Borough of Milltown in expected cases of high rainfall or spillway discharge.

Robert Gershowitz, P.E.

Robert Gershowitz, P.E.

STATE OF NEW JERSEY
ROBERT GERSHOWITZ
20812
LICENSED
PROFESSIONAL ENGINEER

May 1978

FARRINGTON DAM

RARITAN RIVER BASIN
FARRINGTON DAM
MIDDLESEX COUNTY, NEW JERSEY
INVENTORY NUMBER: NJ00383

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared by
HARRIS-ECI ASSOCIATES
Woodbridge, New Jersey
for
DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA
JUNE 1978

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

FARRINGTON DAM, I.D. NJ 00383

SECTION 1

1. PROJECT INFORMATION

1.1 General

a. Authority

The National Dam Inspection Act, Public Law 92-367 of August 1972 authorizes the Secretary of the Army, through the Corps of Engineers to initiate a program of safety inspections. The inspection of Farrington Dam was carried out under Contract DACW61-78-C-0100 to the Department of the Army, Philadelphia District, Corps of Engineers by the engineering firm of Harris-ECI Associates of Woodbridge, New Jersey.

b. Purpose of Inspection

The purpose of the inspection and evaluation is to identify conditions which threaten the public safety and thus permit the correction of the conditions in a timely manner by the owners.

1.2 Description of Project

a. General Description of Dam and Appurtenances

Farrington Dam is a concrete gravity structure founded on a red shale formation. The center section of the dam consists of a 300-foot long ungated spillway flanked by non-overflow sections tying into higher ground at each abutment. The upstream face of the dam is vertical and the downstream face is stepped down to the foundation level, each step measuring approximately 3-foot high by 2-foot wide. The overflowing water in the spillway is designed to dissipate its energy on these steps, and no further provisions have been made at the toe of the dam for energy dissipation. The outlet works consists of a series of three inlets on the left non-overflow section adjacent to the spillway, allowing water to be drawn from three levels if desired. Only the mid-level outlet was routinely operable as of the inspection date. The low level outlet is a 30-inch diameter cast iron pipe passing straight through the dam at centerline elevation 29.25. The mid and high-level outlets consist of 24-inch cast iron pipes connected to the low level outlet pipe by means of a common 30-inch diameter riser pipe into which the 24-inch inlet pipes connect. All three outlets are controlled by face mounted gates operated by stands on the top of the left abutment. The downstream end of the 30-inch low level outlet is aligned in plan with the downstream channel of Lawrence Brook. No special provisions for dissipating the energy of the outlet works discharges have been made.

During the 1950's, the downstream face of the dam was resurfaced with a layer of concrete 5 to 7-inch thick. This layer of concrete is in extremely eroded and spalled condition, at places exposing the eroded and spalled base concrete beneath it, which it was designed to protect. Some light vegetation has found root in the eroded face materials.

The dam abutment on the left is steep and leaking near the top. The slope is surface eroded, exposing tree roots on the abutment slope downstream of the dam. The right abutment is less steep, but also leaks, with the leakage forming a small rivulet downstream of the dam.

The area downstream of the spillway is partly blocked by a spit of land overgrown with trees. Water coming over the spillway has formed a narrow channel parallel to the dam axis that connects on the left to the Lawrence Brook Channel.

The downstream channel of Lawrence Brook is well defined in a steep sided valley. The banks are overgrown with trees almost down to the normal tailwater line. There are no residences immediately downstream of the dam, but there are residences and commercial structures adjacent to the normal flood plain in the downstream community of Milltown.

The reservoir rim is moderately sloping to flat, and covered by trees. Very little development exists along the shoreline. The shoreline has no protection. The condition along the shoreline indicates that the lake rarely rises above a level of 15 to 18 inches above the spillway crest.

b. Location

Farrington Dam is located on Lawrence Brook, upstream of the brook crossing at Riva Avenue. It straddles the township line dividing East Brunswick and North Brunswick, in Middlesex County, New Jersey. Lawrence Brook is a tributary of the Raritan River.

c. Size Classification

According to the "Recommended Guidelines for Safety Inspection" by the U.S. Department of the Army, Office of the Chief Engineers, the dam is classified in the dam size category as being "Intermediate", since its storage is more than 1,000 acre-feet, but less than 50,000 acre-feet. The dam is also classified as "Small" because its height is less than 40 feet. The overall size classification is governed by the larger of these two determinations, and accordingly, Farrington Dam is classified as "Intermediate" in size.

d. Hazard Classification

The dam has been classified as having High Hazard Potential in the National Inventory of Dams, on the basis that in the event of failure of the dam and its appurtenances, excessive damage could occur to downstream property together with the possibility of the loss of more than a few lives. Our findings concur with this classification.

e. Ownership

Farrington Dam is owned by the City of New Brunswick.

f. Purpose of Dam

The dam is operated as a water supply storage reservoir. Auxiliary uses include small non-powered boating and fishing.

g. Design and Construction History

According to plans furnished by the Owner, the dam was designed in 1926 and signed by the City Engineer in charge at that time. No data has been uncovered as to its construction history in the New Jersey Department of Environmental Protection files. The dam was rehabilitated by adding a surface layer of protective concrete to the downstream face sometime in the 1950's according to the City Engineer. No drawings for this work are on file at the New Jersey Department of Environmental Protection or with the City Engineer.

h. Normal Operating Procedures

The normal operating procedure is to allow the reservoir water to flow over the spillway, keeping the low level outlet closed. Water discharging over the spillway continues down the natural channel of Lawrence Brook and is impounded again at Weston's Mill Pond Dam for water supply releases. Water releases from Farrington Dam are coordinated with water supply needs at Weston's Mill Pond, and releases are made through the dam's outlet gates in late summer and early fall when the water level of Farrington Lake usually falls below the spillway level. The minimum release is 3.5 million gallons per day (5.4 cfs).

1.3 Pertinent Data

At the dam axis, drainage area is 34.4 square miles.

b. Discharge at Dam Site

Maximum known flood at dam site:	4,920 cfs on July 21, 1975: reservoir level 52.60 MSL
Warm water outlet at pool elevation:	55 cfs at Elev. 52 (estimated)
Diversion tunnel low pool outlet at pool elevation:	NA
Diversion tunnel outlet at pool elevation:	NA
Gates spillway capacity at pool elevation:	NA
Ungated spillway capacity at maximum pool elevation:	2,710 cfs, at Elev. 52
Total spillway capacity at maximum pool elevation:	2,710 cfs, at Elev. 52

c. Elevation (feetabove MSL)

Top of dam:	53.0
Maximum flood control pool:	NA
Full flood control pool:	NA
Recreation pool:	50.0
Spillway crest:	50.0
Upstream portal invert diversion tunnel:	NA
Downstream portal invert diversion tunnel:	NA
Streambed at centerline of dam:	27.5
Maximum tailwater:	37.2 at 4,920 cfs (estimated)

d. Reservoir

Length of maximum pool:	4.25 miles (Elev. 52.0)
Length of recreation pool:	3.50 miles (Elev. 50.0)
Length of flood control pool:	NA

e. Storage (acre-feet)

Recreation pool:	2,450 AF (Elev. 50)
Flood control pool:	NA
Design surcharge:	2,900 AF (Elev. 52)
Top of dam:	3,142 AF (Elev. 53)

f. Reservoir Surface (acres)

Top dam:	250 (Elev. 53)
Maximum pool:	233 (Elev. 52)
Flood-control pool:	NA
Recreation pool:	211 (Elev. 50)
Spillway crest:	211 (Elev. 50)

g. Dam

Type:	Concrete gravity
Length:	535 feet
Height:	34
Top width:	4 feet
Side slopes - Upstream:	Vertical
- Downstream:	Stepped 3V on 2H
Zoning:	NA
Impervious core:	NA
Cutoff:	None
Grout curtain:	No information available

h. Diversion and Regulating Tunnel

Type:	NA
Length:	NA
Closure:	NA
Access:	NA
Regulating facilities:	NA

i. Spillway

Type:	Ungated modified ogee
Length of weir:	300 feet
Crest elevation:	50.0
Gates:	None
U.S. Channel:	None
D/S Channel:	Lawrence Brook, natural Channel

j. Regulating Outlets

Low level inlets:	#1	24-in.dia.-℄ Elev. 48.0 (inoperable)
	#2	24-in.dia.-℄ Elev. 38.67 (operable)
	#3	30-in.dia.-℄ Elev. 29.25 (believed inoperable)
Controls:		Slide gate valves mounted on upstream face of dam
Emergency gate:		None
Outlet:		30-in. dia. cast iron pipe, ℄ Elev. 29.25

SECTION 2

2. ENGINEERING DATA

2.1 Design

The only design data uncovered are two signed contract drawings dating to 1926 showing the dam configuration (Drawings 2 and 3, appended in "Plates"). No computations relating to spillway discharge capacity, hydrology or hydraulics were uncovered. Gage records are available correlating the discharge at Farrington Dam with the reservoir level, maintained by the U.S. Geological Survey. (USGS gage, "Lawrence Brook at Farrington Dam" 1927- present). A stage discharge relationship for the reservoir is kept by the U.S.G.S. The State of New Jersey Department of Environmental Protection (NJ-DEP) has shown stream flood profiles for Lawrence Brook at Farrington Dam for the 100-year discharge (3,600 cfs) and for 125 percent of the 100-year discharge (4,500 cfs).

A primitive stability assessment of the dam is shown on one of the contract drawings, depicting the location of the resultant of forces on the base plane. This analysis is considered inadequate according to current criteria.

No design data on the overlay concrete was uncovered during this phase.

2.2 Construction

No data on construction has been uncovered for this phase of the investigation in the files of the New Jersey Department of Environmental Protection.

2.3 Operation

Reservoir levels are recorded at the U.S.G.S. gage "Lawrence Brook at Farrington Dam". Records of low level outlet gate openings are sent to the U.S.G.S. offices in Trenton, New Jersey, for estimation of total brook discharges over the spillway and through the low level outlets.

2.4 Evaluation

a. Availability

Available data is sparse. It is recommended that further search for original design, construction, and operating data be conducted by the Owner. Needed for further assessment of stability are:

1. Engineering properties of the foundation shale material.

2. Determination of uplift pressures under the dam and abutments.

3. Effect of reservoir backfill and siltation on uplift pressures.

4. A cross section survey of the dam depicting the original concrete construction and the extent of the concrete overlay repair at various key cross sections.

5. A survey of the toe of the dam to determine downstream spillway channel depths and degree of rock erosion and undercutting of the gravity section

of the dam, if any. Data from the most recent inspection of the toe of dam may be used if less than 5 years old.

b. Adequacy

The available data is inadequate to determine the safety of the dam in regard to stability. It is recommended that data acquisition listed under "Availability" be implemented.

c. Validity

The data uncovered in this phase is considered valid. The two simple drawings of the dam basically correspond to the structure which is actually existing on the site, except for uncertainty as to the exact foundation level of dam as actually built.

S E C T I O N 3

3. VISUAL INSPECTION

3.1 Findings

a. General

Farrington Dam has suffered extensive concrete surface deterioration on its downstream face. Its present condition requires increased maintenance to assure its continued serviceability.

b. Dam

The concrete dam is seriously deteriorated on its downstream surfaces, which is of stepped configuration in order to provide some measure of energy dissipation to the water flowing over the spillway crest. At some time in the 1950's, the then deteriorated downstream face concrete was repaired by overlaying it with a nominal 6-inch thick layer of lightly reinforced facing concrete, which was dowelled into the original mass concrete with small diameter (1/4 inch) pencil rods. The overlay concrete has in the intervening years of service deteriorated severely itself, by freeze-thaw action and by the erosive action of the water passing over the spillway crest. In places, the overlay concrete is completely spalled away, revealing the original spalled and eroded monolith concrete. Overlay reinforcement and dowelling is exposed in many places, rusted and ruptured in many others. The irregular surfaces created by the erosive action hold and pond water and accelerate the freeze-thaw deterioration in the winter seasons. The deterioration is especially severe on the horizontal surfaces of the stepped face.

The spillway crest, also apparently repaired, is in slightly better condition than the remainder of the dam face, although also severely eroded. In places, such as adjacent to the left non-overflow section the spillway crest repair concrete, it is completely missing for a distance of several feet creating an uneven crest elevation of approximately 3 to 4 inches. There is a slight deviation from line visible in the crest at the middle of the spillway, but this is not thought to be in connection with movement of the dam monolith itself, but rather caused by a poor alignment of the overlay concrete forms.

The overlay concrete obscures the original monolith joints and they are hard to discern on the downstream face. It is hard to ascertain where the overlay concrete facing was jointed, because of the severe deterioration of the surface. One monolith joint in the base concrete was found on the downstream face, in a spalled condition beneath the deteriorated overlay facing. Two monolith joints were observed on the back face of the dam, one each in the middle of the non-overflow sections adjoining the central spillway. These joints are also severely spalled. The only construction drawings available do not show any monolith jointing. No construction joints are visible except on the back face of the dam where two cracked horizontal construction joints are visible very close to the top of dam.

The non-overflow sections of the dam are also stepped and no spillway training wall was provided in the design, at the ends of the spillway to confine the overflowing water to the spillway section itself. The condition of the overlay concrete on the downstream face of the non-overflow sections is slightly better than on the central spillway due to the absence of erosive action of water further away from the spillway. Some brush growth has taken root on the steps of the left non-overflow section.

Seepage was observed coming out high up on the left abutment's downstream face, approximately at the reservoir level and estimated at one gallon per minute.

A more significant seepage occurs along many points at the toe of the dam and at the dam face on the right abutment. Seepage points, under pressure, extend for several tens of feet. Calcite films along the downstream face indicate minor seepage through construction joints. However, the major seeps may be exit points for water moving either (1) through construction joints, (2) through rock fractures (or alluvial gravels), and/or (3) along the contact between the foundation material and concrete. Seepage from this area forms a rivulet running down the right downstream abutment area discharging an estimated two gallons per minute.

High uplift pressure were detected along the toe of the spillway, where leaking water formed a pinhole type geyser attaining a height of approximately one foot above prevailing tailwater surface.

- Dam Foundation

Red shale, cropping out on the left abutment, and probably red, fine-grained sandstone (Brunswick formation) comprise the foundation for the dam. Glacial-fluvial sands and gravels cap a terrace-like plateau beyond the right abutment. It is possible that a section of the right abutment structure may be founded on this alluvial material. Dark silty clays and light-colored sands (Magothy and Raritan formations) mantle the hills upstream of the dam.

- Outlet Facilities

Outlet facilities are built into the body of the left non-overflow section of the dam immediately adjacent to the spillway section.

There are three intakes located at different elevations, all leading to a common 30-inch diameter riser and discharge line. Each intake is controlled by a sluice gate located on the vertical upstream face of the dam.

For discussion, the sluice gates are numbered 1, 2 and 3 from left to right looking downstream. Gate 1 (high level outlet) is a 24-inch square, pressure seating gate; the centerline is at elevation 48. This gate is no longer operable as the operating stand has been removed. A length of 4-inch steel pipe has been installed in its place to protect the threaded stem. There is no means of raising this gate at present.

Gate number 2 (low level outlet) is a 30-inch square, pressure seating gate; centerline elevation at 29.3. The valve operator, manufactured by Coffin Valve Co., is a bevel reduction gear type, driven by a hand crank. Only part of the hand crank remains, the rest having been broken off. According to dam operating personnel, this gate valve has not been operated in years, principally because the water quality at the reservoir bottom is bad and creates problems with water consumers. An attempt would only be made to operate this gate in an emergency situation. It is believed that this gate at present is basically inoperable. Both Number 1 and 2 gate stems are corroded at the water surface. Approximately 60 percent of the original diameter remains (35 percent of the original area).

Gate number 3 (mid-level outlet) is a 24-inch square, pressure seating gate; centerline at elevation 38.7. The valve operator, manufactured by Coffin Valve Co,, consists of a manually operated handwheel acting directly on the threaded valve stem. This gate is operable and was 70 percent open at the time of this inspection. The gate was opened prior to the inspection to draw the reservoir level down below the spillway crest enabling inspection of the downstream face of the dam. According to operating personnel, a section of the stem normally at the water surface has been replaced. This accounts for the lack of severe corrosion of this stem compared to that observed on Gates 1 and 2.

In summary, Gate 3 is operable and in good condition; Gate 1 is inoperable; however, the desirability of repair is debatable since the centerline elevation of this intake is only two feet below the crest of the spillway. Gate 2 has been unused for years and may be inoperable. Without this gate, the reservoir can be drawn no lower than approximately elevation 37.0, which is the invert elevation of the mid-level outlet Gate 3.

The discharge of the common 30-inch diameter outlet line is on the downstream side of the dam at the centerline elevation 29.25, discharging into the downstream channel. The outlet pipe is completely or nearly completely exposed above normal tailwater levels. There are no special energy dissipating devices visible at the outlet pipe. The outlet pipe is approximately aligned in plan with the natural streambed of Lawrence Brook.

c. Appurtenant Structures

None exist.

d. Reservoir Area

The reservoir area was inspected from several locations. No indication of reservoir rim instability were readily apparent. The reservoir rim is solidly under deciduous tree growth. At present, development is very sparse on the shore line. The reservoir rim has no shoreline protection. Judging from the condition of the rim, water levels rarely rise more than 18 inches above the crest of the spillway. This is confirmed by reservoir gaging records maintained by the U.S.G.S. on the left reservoir rim near the dam axis. The reservoir is cut by two causeways, one in the center of the reservoir at Washington Place, approximately 6,000 feet upstream of the dam axis, and one at Church Lane, approximately 13,000 feet upstream of the dam axis. The reservoir is connected by openings approx. 40-foot wide in the causeways, covered by vehicular bridges.

The reservoir has apparently silted over during its service life, and there is an accumulation of organic material in the lake bottom near the dam's low level outlet that makes routine releases from that level undesirable from the water quality standpoint.

e. Downstream Channel

The downstream channel is well defined, but trees and heavy brush cover both banks almost down to the water line. The channel of Lawrence Brook is opposite the outlet works at the left end of the dam, and the area downstream of spillway is blocked by a low peninsula, overgrown with substantial tree and brush cover. Spillway overflow water at the dam's right end must flow parallel to the dam axis in a relatively narrow open channel at the toe of the spillway to gain access to the brook. There is no stone protection visible along the banks of this spillway channel and Lawrence Brook. A good part of the downstream area is of shallow depth and can be waded at normal low tailwater. No precise idea of undercutting of the dam toe could be obtained by visual observations. There are no structures in the immediate area downstream of the dam but there are low lying residential and commercial properties in the Borough of Milltown that could be affected by high stream stages.

3.2 Evaluation

The areas of concern in regard to the safety of Farrington Dam center on the following points:

1. Deterioration of the Downstream Face Concrete:
   It is obvious that the same corrective action is needed to rehabilitate the spillway face to maintain serviceability. In view of the expenses involved, the final decision on corrective action is heavily dependent on the overall solution to other deficiencies related to spillway capacity and dam stability.

2. Seepage and Leakage:
   The seepage at the right abutment is a safety concern, since it erupts at many points and the origin and path of this seepage is unknown. The high uplift pressures in the form of geysers were noted at the toe of the dam. The extent and magnitude of the uplift pressures along the foundation plane is unknown.

3. Foundation:
   Farrington Dam is built on a soft shale formation which has shown tendencies toward erosion and undercutting of the dam toe at spillway sections and adjacent to low level outlets in other dam installations.

4. Outlet Facilities
   Gate No. 1 (high level) has a missing operating stand and is inoperable. Gate No. 2 has not been operated in years and is assumed to be inoperable. Gate No. 3 (mid-level) is operable.

5. Downstream Channel

The area downstream of the spillway channel is narrow and partially obstructed by a tree-grown peninsula. The transition between zone banks and bottom is poorly defined and unprotected against scour.

SECTION 4

4. OPERATIONAL PROCEDURES

4.1 Procedure

The operation of Farrington Dam is simple in line with the simple facilities provided. The lake level is generally determined by the run-of-the river discharges passing over an uncontrolled fixed concrete spillway. During periods of low flow when the level of the lake drops below the crest, water supply requirements are met by operation of the mid-level outlet gate. A minimum flow of 5.4 cfs (3.5 MGD) is maintained.

4.2 Maintenance of Dam

There is no general routine program of maintenance, and repairs are made on an as-needed basis. Prior to the current inspection, the dam was inspected in 1976 by Mr. Robert Kane, P.E., City Engineer, City of New Brunswick, at the request of the N.J. Department of Environmental Protection, and found in serviceable condition.

4.3 Maintenance of Operating Facilities

The low level outlets are maintained in connection with periodic visit to the dam by personnel of the City's Water Department. The controls for the gates are in the open and could be subject to vandalism and pranks.

4.4 Description of any Warning System in Effect

We have no knowledge of any warning system in effect that would alert downstream residents of impending high water levels or possible dam misfunction.

4.5 Evaluation

Maintenance has been at a minimal level at the dam. A formal annual check of the dam should be initiated using a format similar to the visual check list used in this report and appended in Appendix A. Foundation seepage should be channelized, monitored and have its volume estimated at monthly intervals to determine its stability. The vegetative growth in the area downstream of the spillway should be controlled from its current wild state.

A warning system should be established with the police or civil defense officials in the downstream Borough of Milltown to provide an alert in cases of exceptionally high rainfalls and high spillway discharges.

SECTION 5

5. HYDRAULIC / HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

Farrington Dam is located on Lawrence Brook approximately 5.2 miles upstream from its confluence with Raritan River. The drainage area of Lawrence Brook at Farrington Dam is approximately 34.4 square miles. The main tributaries of Lawrence Brook above the Farrington Dam are Great Ditch, Oakleys Brook, Ireland Brook and Beaver Dam Brook. A map showing the drainage area of Lawrence Brook at Farrington Dam is presented in Plate 1, Appendix D.

Lawrence Brook follows a winding course. The topography is characterized by low hills at the head waters and lower lands, depressed and swampy lands along most of the lower portion of Lawrence Brook and its tributaries.

Land use patterns along Lawrence Brook are mostly residential with some agricultural uses. Residential developments are concentrated in the lower reach of the Lawrence Brook.

The basin is serviced by two major divided highways which provide stimulus to industrial and residential growth in the basin. These two highways are U.S. Highway 130 to the northwest and the New Jersey Turnpike to the southeast.

The evaluation of the hydraulic and hydrologic features of Farrington Dam was based on criteria set forth in the Corps' Guidelines, Section 4.3 and additional guidance provided by the Philadelphia District Corps of Engineers. The Probable Maximum Flood (PMF) was calculated from the

Probable Maximum Precipitation using Hydrometeorological Report No. 33 with standard reduction factors. The Snyder Method was used for deriving the unit hydrograph with the following equations:

$$t_c = 8.29\,(1.0 + 0.03I)^{-1.28} \left(\frac{D.A.}{S}\right)^{0.28}$$

$$\frac{R}{t_c + R} = 0.65$$

where:

D.A = drainage area in square miles.

S = water course slope, in feet per mile, defined as the average slope of the water course between points 10 and 85 percent of the distance upstream from the runoff site to the watershed boundary.

I = index of impervious cover in percent of total land area.

t_c = time in hours from the end of a burst of rainfall excess to the inflection point on the recession limb of the resulting direct runoff hydrograph (Clark method).

R = discharge at the inflection point on the recession limb of the direct runoff hydrograph divided by the slope of the recession limb at that point, in hours (Clark method).

The computed t_c and R for Farrington Dam are 4.88 hours and 9.08 hours respectively. The hydrologic/hydraulic computations are presented in Appendix D, Hydrologic Computations and HEC-1 computations.

Initial infiltation loss rates were applied using SCS procedures to the Probable Maximum Storm rainfall to obtain rainfall excesses. The rainfall excess was then applied to the unit hydrograph to obtain the PMF hydrograph, utilizing computer program HEC-1. The computed peak discharge of PMF and one half of the PMF are 29,036 cfs and 14,518 cfs respectively.

These inflow hydrographs were routed through the reservoir by the modified Puls method utilizing computer program HEC-1. The peak outflow discharges for the PMF and one half of PMF are 28,095 cfs and 14,002 cfs respectively. Both the PMF and one half of the PMF result in overtopping of the dam.

The stage-outflow relation for the spillway and the reservoir stage-capacity data were based on the U.S.G.S. quadrangle topographic maps. Reservoir storage capacity included for surcharge levels exceeding the top of dam and the spillway rating curve above the top of dam assumed that the dam remains intact during routing. In the routing computations, the discharge through outlet facilities was excluded due to its insignificant magnitude as compared to the spillway discharge and the PMF. The spillway rating curve and the reservoir capacity curve are presented in Plates 2 and 3 of Appendix D respectively.

b. Experience Data

The recorded history of flooding in the Lawrence Brook Basin began in 1922 when the U.S. Geological Survey (U.S.G.S.) gaging station, #01404500, was installed at Patricks Corner. With the completion of the nearby Farrington Dam in 1927, the Patricks Corner gaging station was disconnued; and its replacement, U.S.G.S. gaging station, #01405000, at

Farrington Dam has been recording from 1927 to the present. During this time, several major floods have occurred and minor floods have been a common occurrence. The dates of twelve major flooding events (1,500 cfs or more) are as follows:

July 17, 1927
October 18, 1927
July 6, 1928
September 21, 1938
September 15, 1944
July 24, 1959
March 7, 1967
May 29, 1968
August 28, 1971
June 24, 1972
February 2, 1973
July 21, 1975

On August 27-28, 1971, New Jersey was hit by Hurricane Doria causing the President to declare New Jersey a natural disaster area. An extensive high water survey was conducted jointly by the State of New Jersey and the U.S.G.S. following Doria; these data are on file with NJ-DEP, Division of Water Resources. According to field data, the flooding caused by Hurricane Doria is estimated to have exceeded the flood crest of the previous flood of record on September 21, 1938, by approximately two tenths of a foot.

A maximum discharge of 2,980 cfs was recorded for U.S.G.S. gaging station #01405000 on Lawrence Brook at Farrington Dam, on August 28, 1971. Since that time, the maximum known discharge at Farrington Dam occurred on July 21, 1975 with a discharge of 4,920 cfs at reservoir elevation 52.60, exceeding the Hurricane Doria stage by 0.60 of a foot (top of dam is elevation 53).

The adopted design discharge for floodway delineation at this point is 3,150 cfs based on Flood Hazard Report No. 7 by the State of New Jersey Department of Environmental Protection, dated September 1972.

The computed PMF value is 5.7 times larger than the 1975 flow at the Farrington Dam site.

c. Visual Observations

There is no evidence of excessive sedimentation due to recent developments in the drainage basin that would affect the storage capacity of the dam and its safety. The spillway crest is uneven but does not materially affect the rating curves established for PMF analyses.

d. Overtopping Potential

As indicated in Section 5.1 - a. both the Probable Maximum Flood and the one half of the Probable Maximum Flood, when routed through the Farrington reservoir result in overtopping the dam. The PMF and one half PMF overtopped the dam by 4.10 feet and 1.90 feet respectively.

The spillway is only capable of passing a flood equal to 22 percent of the PMF without overtopping the dam. Since PMF is the Spillway Design Flood (SDF) for this dam, according to the Recommended Guidelines for Inspection of Dams by the Corps, the spillway capacity of the Farrington Dam is considered seriously inadequate.

e. Reservoir Drawdown

The reservoir drawdown below the spillway crest elevation 50.0 is accomplished by permitting discharge through the 30-inch bottom outlet pipe, with an invert elevation of 28.0 MSL. Assuming drawdown to the top of the pipe, elevation 30.5 results in a maximum head differential of 19.5 feet. If a constant inflow of 2 cfs per square mile of drainage area is assumed, the resultant inflow into the reservoir would amount to 68.8 cfs, which is greater than the rated outlet capacity of the bottom level outlet. The reservoir could not be drawn down under these conditions. Assuming no inflow into the reservoir, the drawdown could be accomplished in 44.5 days.

SECTION 6

6. STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The apparent high uplift pressure observed at the toe of the spillway gives rise to concern about the stability of the structure, as does the leakage coming out of the right abutment section. The foundation material, Red Brunswick Shale, is erodible and has exhibited tendencies toward undercutting when exposed to rapidly moving water on other nearby dams. It also has a low angle of internal friction and a low unit shear strength which may give difficulty in achieving a satisfactory factor of safety in evaluating sliding resistance.

b. Design Construction Data

The only design data relating to stability is a force diagram on one of the contract drawings uncovered, showing the resultant of the upstream water pressure and dam weight intersecting the foundation plane within the middle third. No uplift pressures on the base plane were considered in this analysis, and it is considered insufficient for determining the stability of the dam.

No construction data is available for assessing the various factors relating to the foundation normally considered in a stability analysis for a gravity section.

A preliminary stability analysis for the maximum section shows that the dam would be unable to meet acceptable Corps of Engineers' stability analysis criteria for location of resultant force on the base plane using full head water and tailwater uplift pressures at the heel and toe of the dam respectively. A rationale for reducing the uplift pressures on the foundation plane could be the presence of extensive silt deposits at the heel which would reduce the head water pressure at the heel by providing a longer seepage path for dissipating the differential pressure existing between head water and tailwater. This effect is normally not considered, because such silt deposits could at any time be dredged out.

c. Operating Records

The dam has withstood all high water events since construction in 1926, with lake levels up to elevation 52.60 according to U.S.G.S. gage records. Concern has been expressed as to its safety by a downstream resident according to a letter in the files of the NJ-DEP.

d. Post Construction Changes

The addition of a 6-inch thick facing layer of concrete should improve the stability somewhat even though it is deteriorated, because all that is needed for stability considerations is weight. The possibility exists that the overlay concrete has blocked off leakage and seepage water normally existing in open monolith joints, thus increasing uplift pressures on any horizontal plane through the dam or its foundation, which would be detrimental to stability. The overlay concrete is currently so deteriorated that this condition probably cannot exist.

e. Seismic Stability

The dam is located in a Zone 1 of the Seismic Zone Map of the United States. Due to the low height of the dam, the risk of seismic damage is probably low, but the effect of seismic loadings should be verified at the time the overall stability of the dam is reevaluated on the basis of complete engineering data.

SECTION 7

7. ASSESSMENT / REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety

The dam has been inspected visually and a review has been made of the available engineering data. This assessment is subject to the limitations inherent in the visual inspection procedures stipulated by the Corps of Engineers for Phase I Report.

The safety of Farrington Dam is questionable since it cannot pass the PMF or one half on the PMF without overtopping. The dam's stability is in question since it apparently was designed without considering uplift forces on the base plane. A preliminary evaluation of the stability of the dam shows that it would have difficulty in meeting current Corps of Engineers' stability guidelines at current maximum pool levels. This would also apply to even higher pool levels if the PMF or one half PMF are to be passed safely without overtopping. Other factors casting doubts on the dam's safety are:

1. High uplift pressure detected at the toe of the dam. Seepage detected on the right abutment area.

2. Uncertainties about the actual foundation level, the quality of the shale underlying the dam, and possible erosion and undecutting of the toe since the last inspection.

3. General deterioration of the dam, such as the severely spalled concrete at downstream face and spillway crest, the inability to operate the low and high level outlet gates and the overgrown spillway channel immediately downstream of most of the spillway width.

b. Adequacy of Information

The information available is not considered adequate to evaluate the safety of the dam at present. Required information includes:

1. Updating of existing dam drawings to include the original construction as well as the facing repairs. Addition of monolith and construction joint data.

2. Acquisition of foundation data by a program of borings to determine the dam/foundation interface along the axis of the dam. Determination of dam concrete and subgrade rock engineering properties.

3. Examination of the toe of the dam for erosion of rock undercutting of the tow. Evaluation of existing inspection data in the files of the owner.

4. Determination of uplift pressures at various points along the base of the dam including points along the heel and toe of the dam. Correlation of uplift pressures with siltation behind the dam.

5. Determination of silt levels adjacent to the dam heel.

6. Monitoring of seepage along right abutment and determination of its source and path to the point of visible leakage.

c. Urgency

1. The restoration of the mid and low level outlets to full operational use should be complete within six months.

2. The data acquisition, listed in Section 7.1.b., should be performed within one year. The necessity of dredging the area in back of the heel of the dam should be considered in the light of conclusions reached in regard of the effect of siltation levels on uplift pressures measured at the base of dam.

3. Downstream channel improvements, at the spillway, to provide a better transition to the natural channel of Lawrence Brook should be completed within 12 months.

4. Formulation of a plan to increase the spillway capacity together with investigations of dam stability to meet currently acceptable criteria at possibly higher pool elevation should be completed within 18 months. The plans for rehabilitation of the spillway face should be part of the additional stability investigations.

d. Necessity for Additional Investigation

In view of the lack of definitive data on which to base a safety assessment, further investigations are recommended.

7.2 Remedial Measures

a. Alternatives

The alternatives available depend on the final spillway capacity recommended, the resulting maximum pool level, and its effect on meeting currently acceptable stability criteria. The site does not readily adapt itself to spillway capacity augmentation by creation of an auxiliary spillway. This solution is merely proposed as a cost comparison alternative. Available alternatives are:

1. Provision of an auxiliary spillway.

2. Raising of the dam's non-overflow sections as required to provide enough head on the existing spillway to pass the additional spillway discharge. Stability may be improved by post-tensioning tendons and/or resurfacing of the downstream face of the dam.

3. Lowering the dam's crest and installation of crest gates, possibly of the automatic bascule leaf type.

All spillway capacity augmentation schemes would have to address the energy dissipation problems associated with higher or more concentrated spillway overflow rates.

b. O & M Procedures

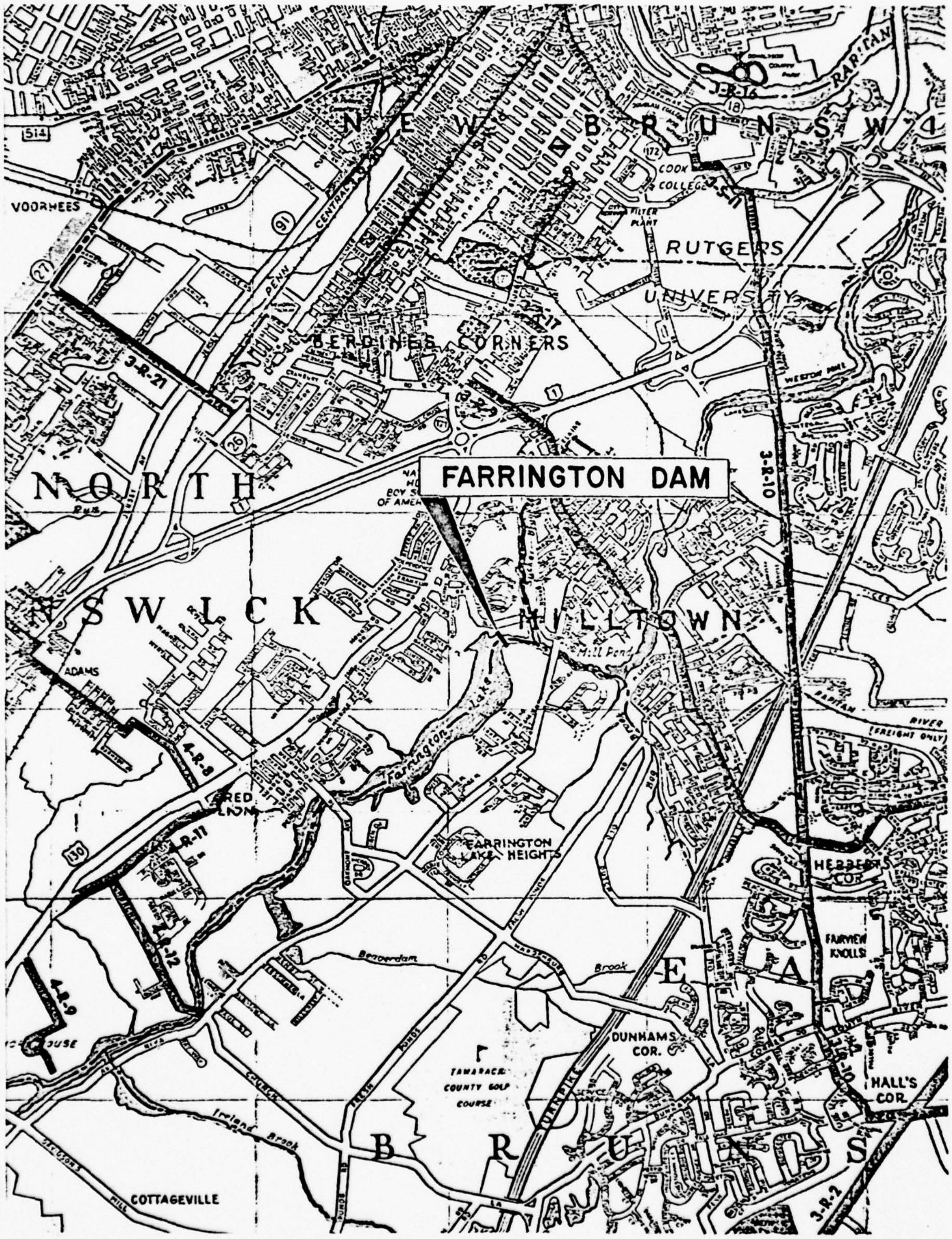
The owner should initiate a program of annual inspection of the dam utilizing the standard visual check list used in this report. The downstream toe of the dam should be dewatered at 15-year intervals and inspected for erosion and undercutting. The first such inspection should be made within twelve months.

A permanent log should be kept of all maintenance and operating events of the dam, the pond and the low level outlet gates. The downstream area at the spillway should be routinely kept free of excessive vegetative growth.

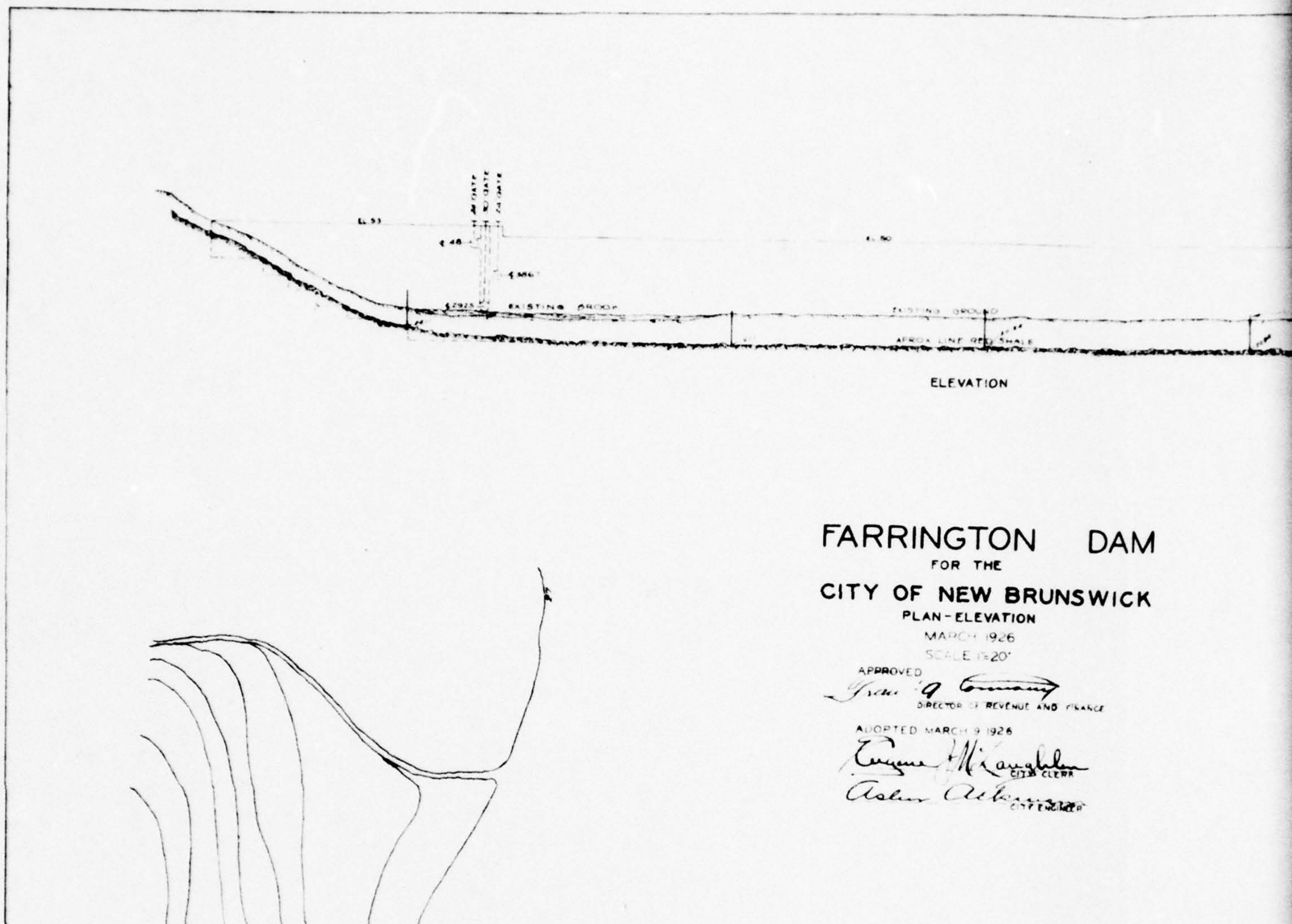
A warning system communications tie line should be established between the City of New Brunswick and the downstream Borough of Milltown in case of expected high rainfall and water levels, until the formulated plan for augmentation of spillway capacity and dam stability is implemented.

An evacuation plan should be developed by the local authorities for those areas of Milltown which would be inundated in the event of flooding due to high flows or dam failure.

PLATES

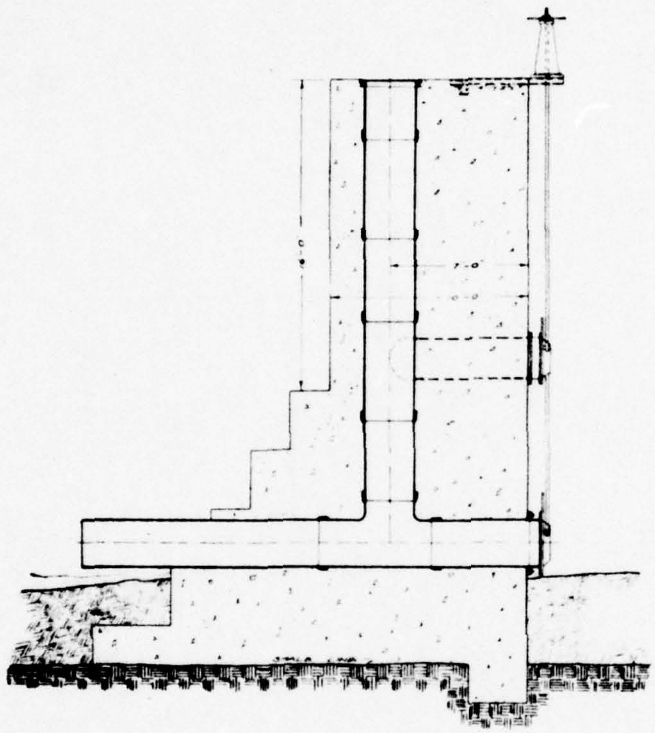


VICINITY MAP

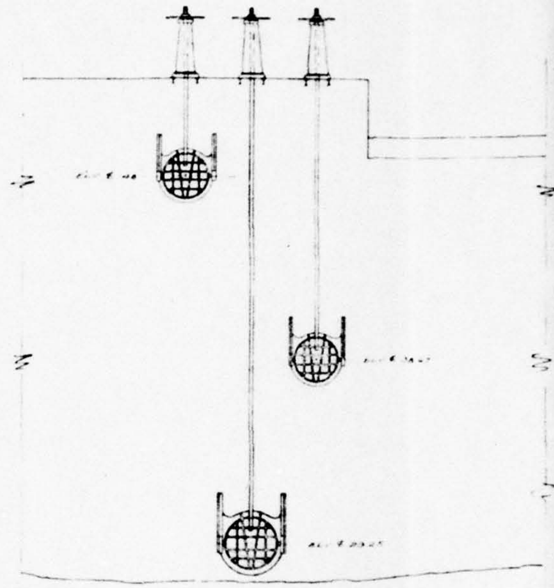

EL 53
EL 48
EL 50
EXISTING GROUND
APROX LINE RED SHALE
ELEVATION
FARRINGTON DAM
FOR THE
CITY OF NEW BRUNSWICK
PLAN - ELEVATION
MARCH 1926
SCALE 1"=20'
APPROVED
DIRECTOR OF REVENUE AND FINANCE
ADOPTED MARCH 9 1926
CITY CLERK
CITY ENGINEER
PLAN

1

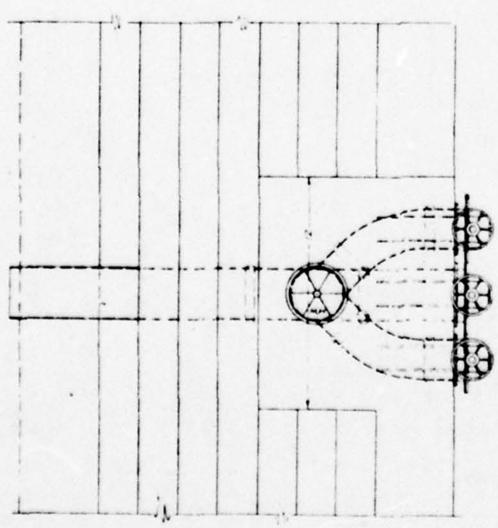

DAM
VICK
DWG. NO. 2



SECTION AT SLUICE GATES

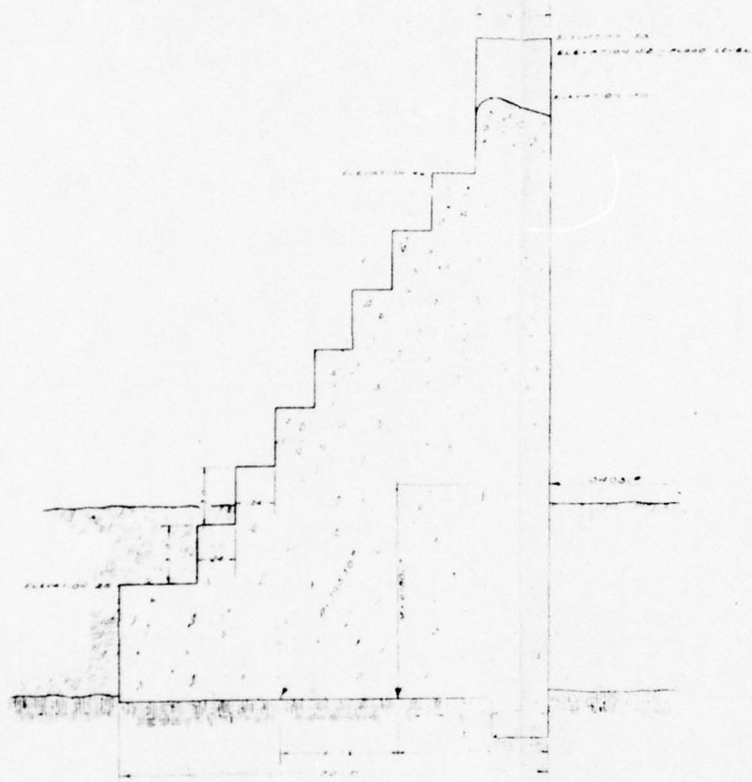


ELEVATION AT SLUICE GATES



PLAN AT SLUICE GATES

GATES



MAXIMUM CROSS SECTION

FARRINGTON DAM

FOR THE

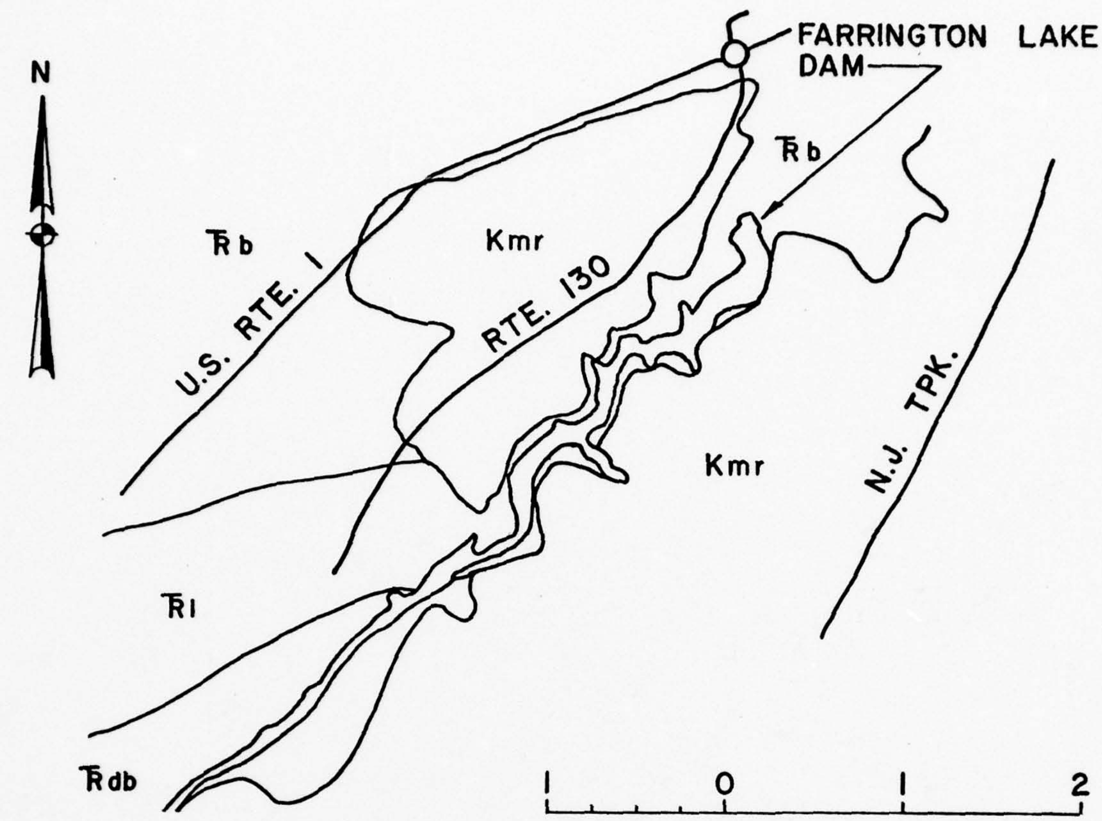
CITY OF NEW BRUNSWICK

DETAILS OF SLUICE GATES - CROSS SECTION

CITY ENGINEER

DWG. NO. 3

2



Scale: 1" = 1 Mile

LEGEND

CRETACEOUS

Kmr — Magothy and Raritan Formations
Dark Silty Clays and Light-Colored Sands (Km);
Alternating Layers of Sands and Clays (Kr)

TRIASSIC

TRb — Brunswick Formation
Soft Red Shale with interbeds of Red Sandstone

TRl — Lockatong Formation
Hard, Dark Argillite with Local Thin Beds of Sandstone

TRdb — Diabase
Coarse-Grained Diabase, Intrusive Dikes in TRb & TRl

——— Contact:

NOTE: Glacial-Fluvial Gravels and Sands on Higher Terraces and Capping Hills and Divides not Shown.

GEOLOGIC MAP

FARRINGTON LAKE

DWG. NO. 4

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION
MAINTENANCE DATA

CHECK LIST
VISUAL INSPECTION
PHASE 1

Name Dam FARRINGTON DAM County Middlesex State New Jersey Coordinators ______

Date(s) Inspection May 4, 1978 / May 8, 1978 Weather Cloudy / Partly Cloudy Temperature 55°F / 65°F

Pool Elevation at Time of Inspection 49.6 M.S.L. Tailwater at Time of Inspection 27.7 M.S.L. (estimated)

Inspection Personnel:

Seymour Roth, May 4 and 8	William Flynn, May 8	Lawrence Woscyna, May 4 NJ-D.E.P.
David Kerkes, May 4 and 8	Lynn Brown, May 8	

Recorder: Seymour M. Roth

Representing the City of New Brunswick: on May 8, 1978
Mr. Harold Kane, Water Department
City of New Brunswick

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SEEPAGE OR LEAKAGE	Right Abutment: 5-10 gpm seepage observed coming from upper end of right abutment, seepage forms a shallow stream 24-in. wide parallel to right abutment. Left Abutment: 1-2 gpm seepage observed coming from upper end of abutment. Spillway: Pinhole leakage geyser seen daylighting vertically from lowest spillway step, apparently due to high uplift.	Collect seepage and monitor volume at weekly intervals
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Visibly eroded soil in front of left abutment, exposing root system of adjacent larger trees. Some small scale erosion due to seepage on right abutment.	
DRAINS	None observed.	
WATER PASSAGES	None available for inspection.	
FOUNDATIONS	Foundation of red Brunswick shale is visible on abutment, horizontally bedded.	

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Entire downstream face of spillway is covered by numerous cracks, eroded concrete and major spalling of a 5 to 7 in. thick overlay facing concrete. The overlay concrete is in an advanced state of disintegration, its dowelling to the original concrete base and mesh reinforcement is completely ruptured in many places. Small shrubs are growing in the decayed overlay concrete.	Resurfacing is a major expense. Recommend further study in conjunction with other deficiencies.
STRUCTURAL CRACKING	No major structural cracking can be observed, although overlay concrete could obscure cracking.	
VERTICAL & HORIZONTAL ALIGNMENT	No visible vertical or horizontal motions can be observed, but actual settlements could be masked by the disintegrated overlay concrete.	
MONOLITH JOINTS	The original monolith joints are generally not visible on the downstream face, however, there are two joints visible on the upstream face, one on each non-overflow section, in a severely spalled state.	
CONSTRUCTION JOINTS	No construction joints can be discerned because of the deteriorated overlay concrete on front face of dam. One or two joints are visible on the back face of the dam, in a cracked state.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	NA	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	NA	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	NA	
VERTICAL & HORIZONTAL ALIGNMENT OF THE CREST	NA	
RIPRAP FAILURES	NA	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	NA	
ANY NOTICEABLE SEEPAGE	NA	
STAFF GAGE AND RECORDER	NA	
DRAINS	NA	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CRACKING & SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	The outlet conduit is apparently lined with an iron liner which can be seen on the downstream face.	
INTAKE STRUCTURE	Intake structure consists of 3 gate valves mounted on the face of the left non-overflow section. Only the middle gate valve is conveniently operable. The lower valve's operating stand has a broken crank and the third operating stand is missing, rendering the upper gate valve practically inoperable. All three gates are surface mounted on the upstream face of the dam.	Rehabilitate gate valves and operating stands to serviceable condition.
OUTLET STRUCTURE	The outlet exits the dam face by means of a 30-inch dia. iron pipe, discharging into the brook channel.	
OUTLET FACILITIES	None	
EMERGENCY GATE	None provided.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONCRETE WEIR	The spillway crest is in a severely deteriorated condition; parts of the overlay concrete near the left abutment and near the center of the spillway are missing. There are no spillway training walls separating the spillway from the non-overflow sections.	Study resurfacing of downstream face and addition of spillway training wall in conjunction with other deficiencies.
APPROACH CHANNEL	None	
DISCHARGE CHANNEL	The brook channel downstream of the dam is blocked for 3/4 of the spillway width by a peninsula on which relatively dense tree growth was observed. At the toe of the spillway a narrow lateral water course connects to the main brook channel.	Regrade area downstream of dam. Provide a smooth zone between spillway and brook approximately 45 degrees in plan on left side of dam. Regrade area, remove trees and provide stone invert and bank protection.
BRIDGE AND PIERS	None	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONCRETE SILL	NA	
APPROACH CHANNEL	NA	
DISCHARGE CHANNEL	NA	
BRIDGE AND PIERS	NA	
GATES & OPERATION EQUIPMENT	NA	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
MONUMENTATION/ SURVEYS	None observed	
OBSERVATION WELLS	None observed	
WEIRS	None observed	
PIEZOMETERS	None observed	
OTHER	U.S.G.S. gaging station "Lawrence Brook at Farrington" in active use on left reservoir shore near dam.	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENTATIONS
SLOPES	Generally moderately steep and tree covered. The water level in the reservoir apparently does not often rise to a level of 18 inches above the spillway crest, judging by the condition of the shoreline. There is no shore protection along the reservoir rim. The reservoir is cut in two places with causeways carrying roads across. The water connection is by a 40-ft. bridge opening in the causeway.	
SEDIMENTATION	There is considerable sedimentation and organic muck on the bottom, which prevents use of the lowest outlet gate because of water quality considerations.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The brook itself has a well defined channel with vegetative cover and trees right down to the water level. The brook however is much narrower than the 300-foot wide spillway and the spillway discharge does not have a proper transition area to feed into the brook.	Provide a wider transition area between dowstream brook channel and spillway.
SLOPES	Downstream bank slopes are steep. There is no slope protection.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	There are no buildings within 500 feet of dam axis. Populated areas, however, exist downstream.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	Available for original construction; not available for major repair.
REGIONAL VICINITY MAP	Available
CONSTRUCTION HISTORY	Not available
TYPICAL SECTIONS OF DAM	Available for original construction; not available for major repair.
HYDROLOGIC/HYDRAULIC DATA	Available for U.S.G.S. gage "Lawrence Brook at Farrington".
OUTLETS - PLAN	Available
- DETAILS	Available
- CONSTRAINTS	Not available
- DISCHARGE RATINGS	Not available
RAINFALL / RESERVOIR RECORDS	Available from U.S.G.S. gage "Lawrence Brook at Farrington".

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
DESIGN REPORTS	None available
GEOLOGY REPORTS	Foundation material is noted on dam drawings.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None available
POST-CONSTRUCTION SURVEYS OF DAM	None Available
BORROW SOURCES	Not known
SPILLWAY PLAN - SECTIONS - DETAILS	Available for original construction; not available as rebuilt.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
OPERATING EQUIPMENT PLANS AND DETAILS	Available for original plans.
MONITORING SYSTEMS	None
MODIFICATIONS	Dam has been refaced in the 1950's with an overlay of 5 to 7 in. of concrete on the downstream face; no details available in document form.
HIGH POOL RECORDS	Available from U.S.G.S. gage "Lawrence Brook at Farrington".
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None uncovered.
PRIOR ACCIDENTS OF FAILURE OF DAM - DESCRIPTION - REPORTS	Dam has not been overtopped according to U.S.G.S. records in 1975.
MAINTENANCE OPERATION RECORDS	None uncovered; low level outlet discharges are being recorded as part of U.S.G.S. gage discharge records.

APPENDIX B

PHOTOGRAPHS

PHOTOGRAPHS TAKEN DURING MAY 1978

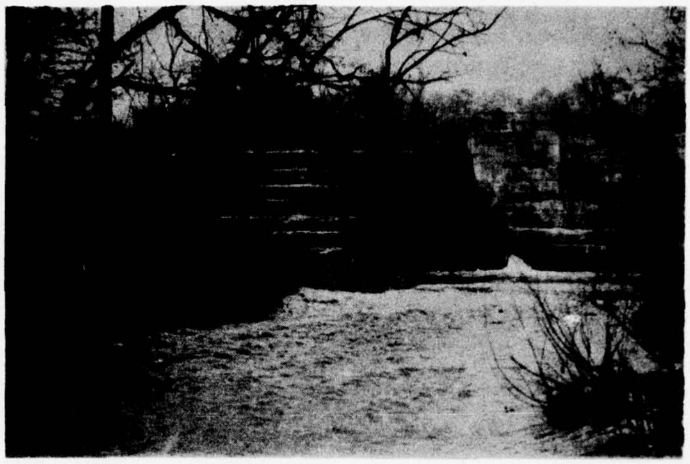


Photo 1 - Downstream face of the dam showing part of the spillway and part of the left non-overflow abutment section; the low level outlet is visible on the right at tailwater level; the downstream channel is partly blocked off by the tree grown peninsula visible on the left of the picture

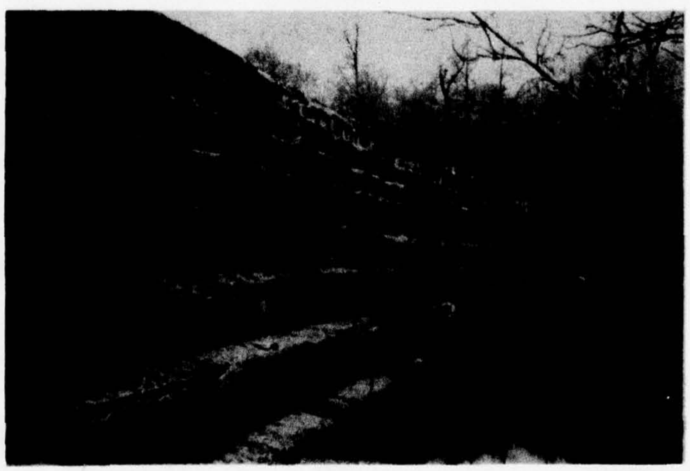


Photo 2 - View of the downstream face of the dam looking toward the left abutment; note the deteriorated face concrete, which is an overlay repair 6-in. avg. thick, placed over the original concrete

Photo 3 - Downstream face of the dam looking toward the right abutment; low level outlet pipe is in the foreground; note that the downstream channel is partly blocked off by the tree grown peninsula; note the absence of spillway training walls between the overflow and non-overflow sections

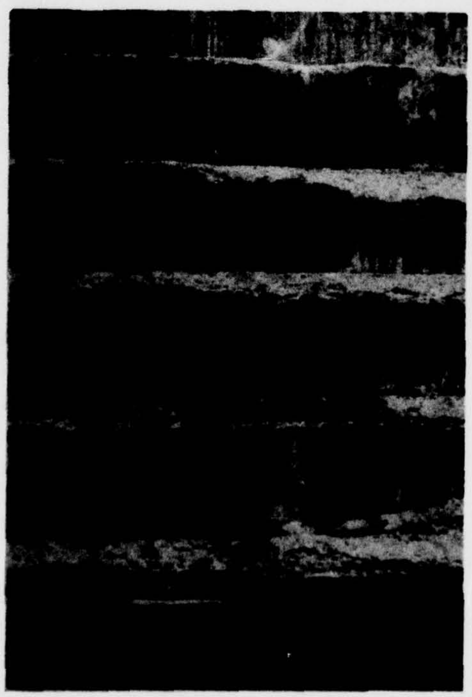


Photo 4 - Detail of the deteriorated downstream face overlay concrete, showing the effects of freeze-thaw spalling and erosion due to overflowing water

Photo 5 - Detail of the deteriorated downstream face concrete overlaying a monolith or construction joint in the original concrete placement

Photo 6 - View across the spillway crest of the dam, looking toward the right abutment, showing the deteriorated crest

Photo 7 - Detail of the spillway crest at the right non-overflow abutment section

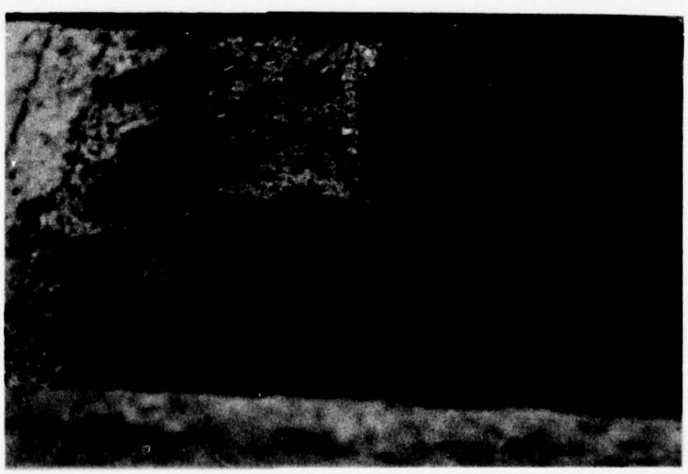


Photo 8 - Detail of the spillway crest at the left non-overflow abutment section, showing missing crest concrete

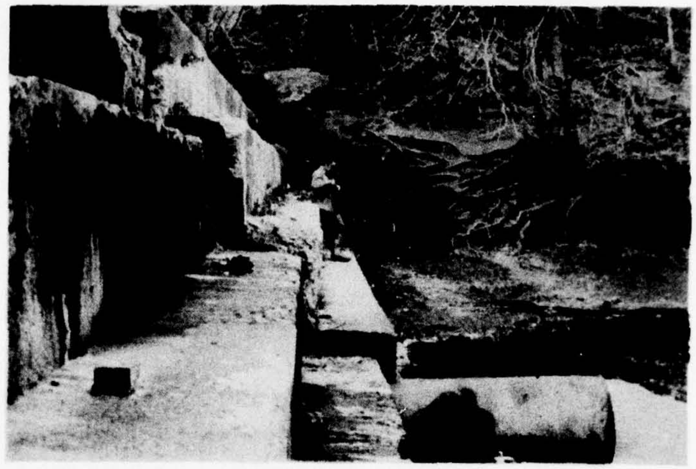


Photo 9 - View of the lower left abutment area downstream of the dam

Photo 10 - View of the upper left abutment area downstream of the dam showing the the general area of seepage at the top of the dam

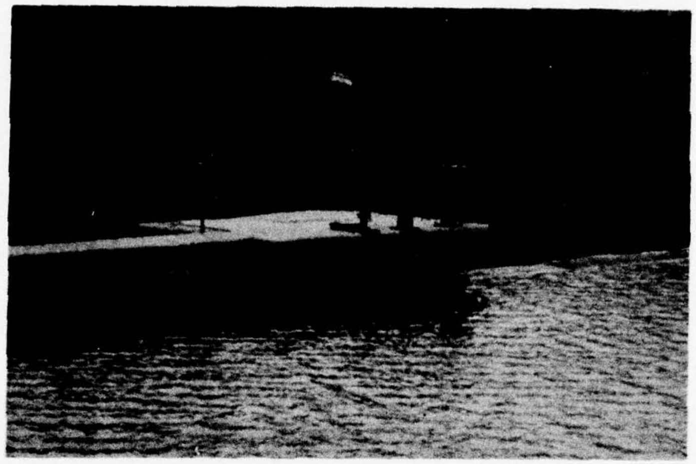


Photo 11 - View of the upstream face of the dam at the left abutment showing the spillway and the outlet works gate operating stands

Photo 12 - View of the upstream face of the dam at the left end of the dam, showing the reservoir gage staff and a deteriorated monolith joint

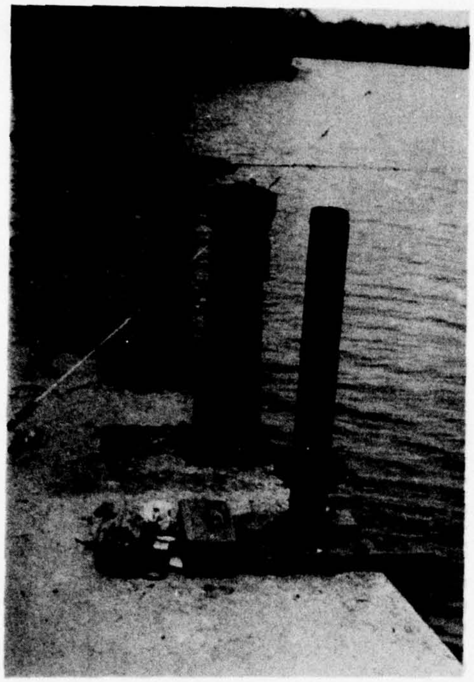


Photo 13 - Close-up of the outlet works gate operating stands; only the far stand, controlling the middle gate is readily operable

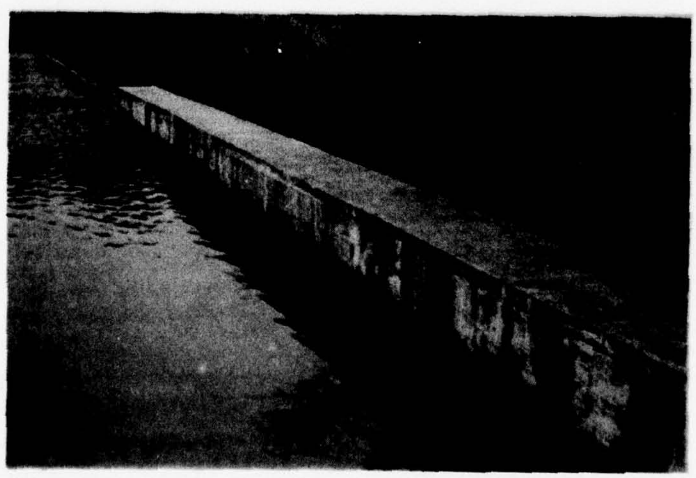


Photo 14 - Upstream view of the right abutment non-overflow abutment section

Photo 15 - View of the downstream channel of Lawrence Brook taken from the left non-overflow abutment section

Photo 16 - Left reservoir rim of the reservoir at the dam, showing the U.S.G.S. gaging station

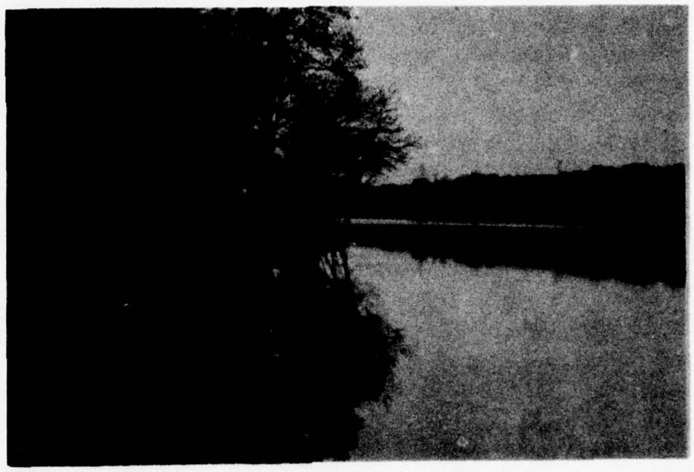


Photo 17 - View of the right reservoir rim looking upstream from the dam

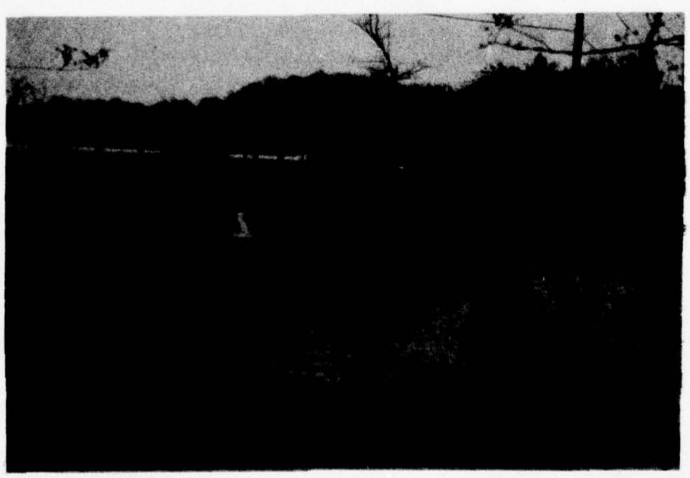


Photo 18 - View of the causeway and bridge crossing the reservoir at Washington Place

APPENDIX C

SUMMARY OF ENGINEERING DATA

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

Name of Dam: FARRINGTON LAKE DAM

Drainage Area Characteristics: 34.4 square miles on Lawrence Brook (Raritan River Basin

Elevation Top Normal Pool (Storage Capacity): 50.0

Elevation Top Flood Control Pool (Storage Capacity): Not applicable

Elevation Maximum Design Pool: 52.0

Elevation Top Dam: 53.0

SPILLWAY CREST:

a. Elevation 50.0
b. Type Uncontrolled concrete overflow weir
c. Width 4 feet
d. Length 300 feet
e. Location Spillover Mid-section of the dam structure
f. No. and Type of Gates None on spillway

OUTLET WORK:

a. Type Multiple inlet, single outlet. Three inlets, high, mid & low level
b. Location Left side of spillway crest
c. Entrance Inverts Elev. 47.0 for upper 24 in. ø
Elev. 37.67 for middle 24 in. ø
Elev. 28.0 for low 30 in. ø
d. Exit Inverts 28.0 single 30 in. ø outlet pipe
e. Emergency Draindown Facilities Low level outlet may be used for this purpose

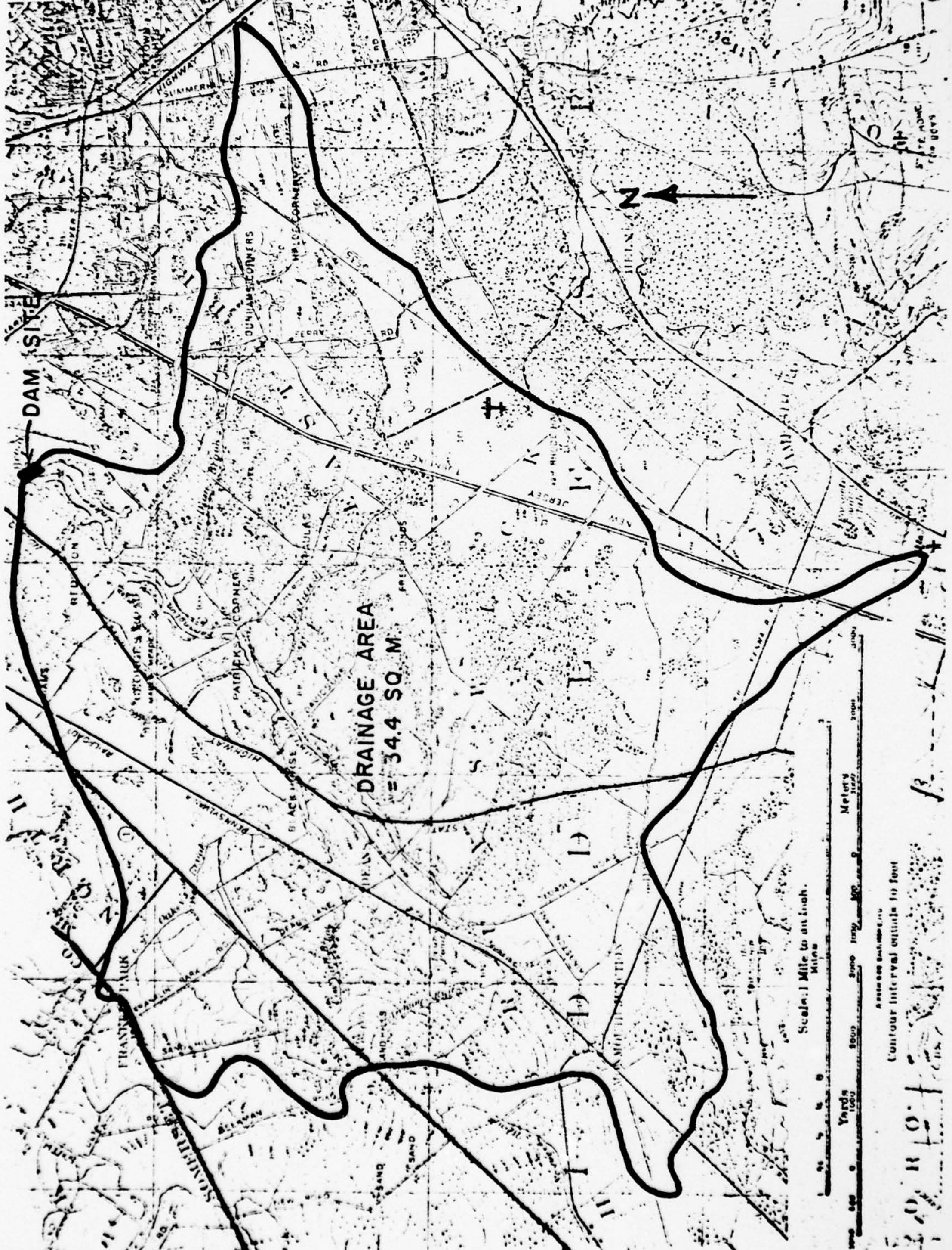
HYDROMETEOROLOGICAL GAGES:

a. Type U.S.G.S. gaging station #01404500/#1040500
b. Location Approx. 300 ft. upstream from the dam on the left shore
c. Records May 1927 to current year

MAXIMUM NON-DAMAGING DISCHARGE 4,920 on July 21, 1975

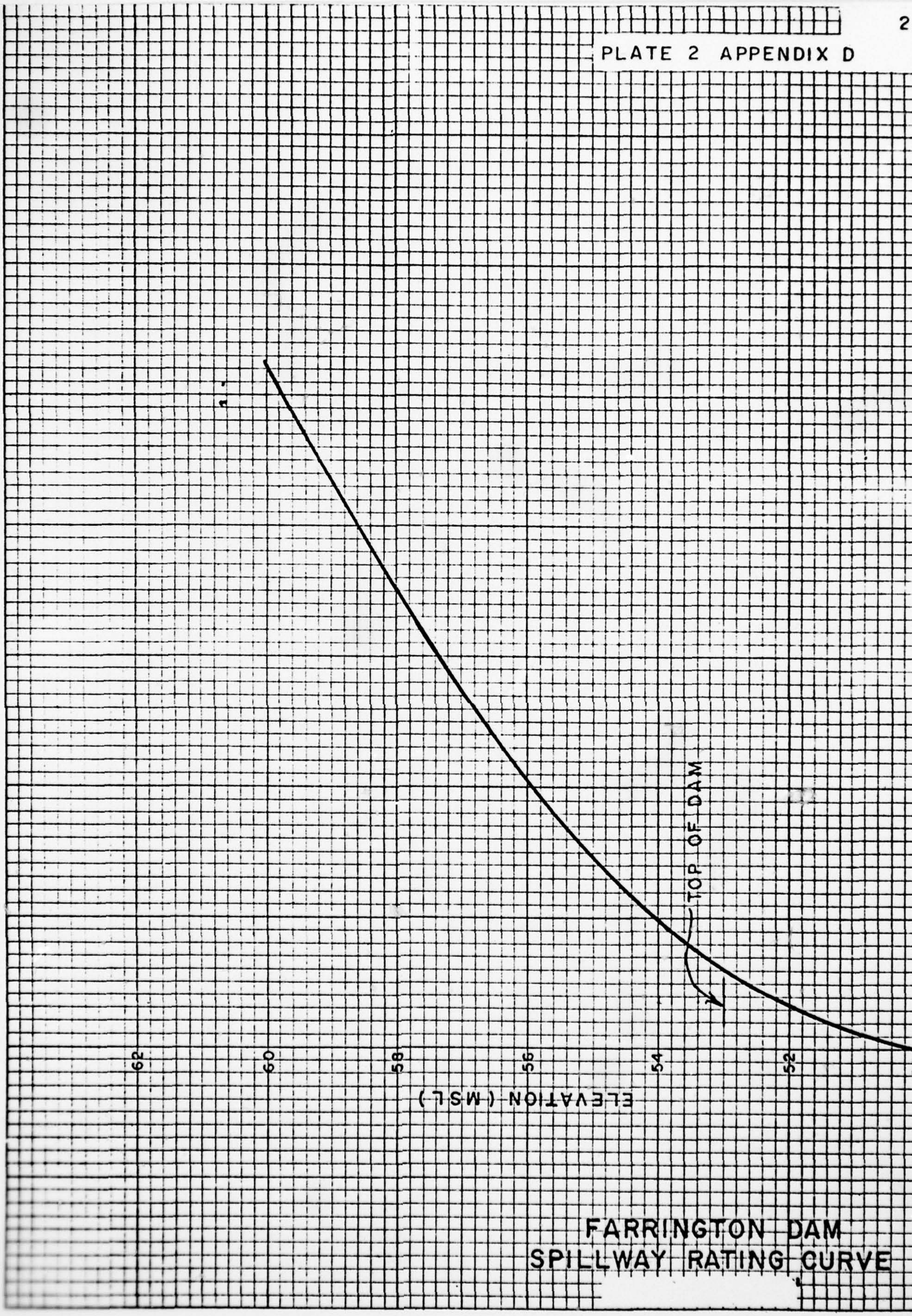
APPENDIX D

HYDROLOGIC COMPUTATIONS



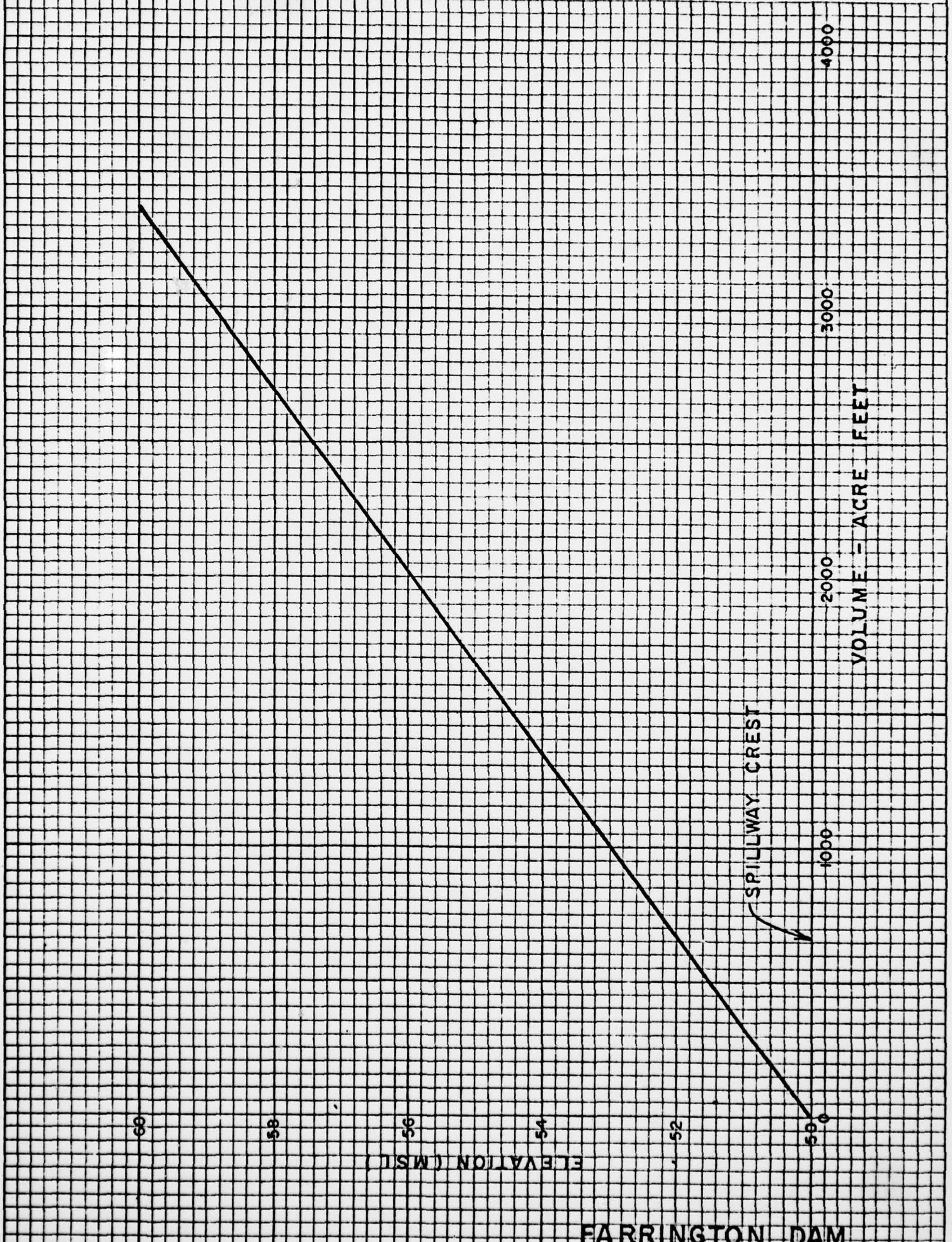
FARRINGTON DAM
DRAINAGE BASIN

PLATE 2 APPENDIX D



FARRINGTON DAM
SPILLWAY RATING CURVE

PLATE 3 APPENDIX D



FARRINGTON DAM
RESERVOIR CAPACITY CURVE

ECI-4 ENGINEERING CONSULTANTS, INC.

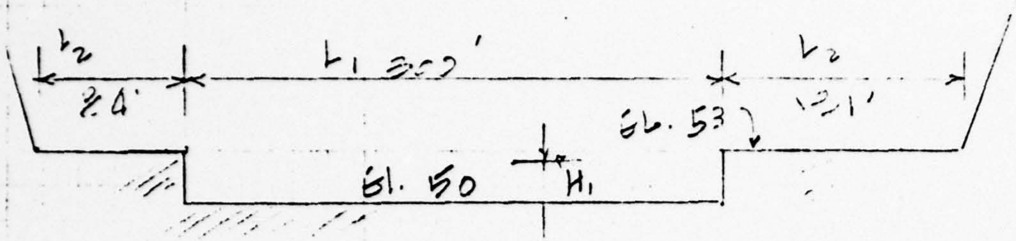
NEW JERSEY DAM SAFETY INSPECTION — SHEET NO. 1 OF 1
FARRINGTON DAM — JOB NO. 1209-001
RESERVOIR AREA CAPACITY DATA — BY MAS — DATE July 7,7

FARRINGTON DAM

RESERVOIR AREA CAPACITY DATA

SUMMARY

Elevation (Feet)	Reservoir Surface Area (Acres)	Reservoir Volume (AC-FT)	NET Vol. Above El. 50	Remarks
50	210	2456	0	Area at El 50 = 210 acres. Assumed that the normal vol. of 2456 is at El 50. (Spillway crest el.).
52	233	2900	444	Assuming maximum volume of 2900 A-F to be at El 52.
53	250	3142	686	Area at top of dam (El 53) is estimated from known areas at 50' & 60' contour (USGS map)
60	465	5645	3189	



ELEVATION	H_1	H_2	L_1	L_2	C_1	C_2	$Q = C_1 L_1 (H_1)^{1.5} + C_2 L_2 (H_2)^{1.5}$
SPILLWAY CREST 50	0	–	–	–	–	–	0
51	1	–	300	–	3.5	–	1050
53	3	–	300	–	3.6	–	5612
54	4	1	300	215	3.7	3.4	9611
55	5	2	300	215	3.8	3.5	14874
57	7	4	300	215	3.85	3.6	27583
59	9	6	300	215	3.90	3.7	43281
60	10	7	300	215	3.9[illegible]	3.8	52130

PROBABLE MAXIMUM FLOOD CALCULATION (PMF)

DRAINAGE AREA = 34.4 square miles.

From Hydrometeorological Report #33
" Seasonal Variation of the Probable Maximum Precipitation East of the 105 th Meridian for Areas from 10 to 1,000 Square Miles and Duration of 6, 12, 24 and 48 Hours" 1956.

For Drainage Area 10 square Miles
the 6 Hour duration PMP is 26 inches for Zone 6 at Carlington Lake watershed.

Since the drainage area is larger than 10 square miles, an area reduction factor of (.90 is applied

The reduced 6 Hour PMP is .90 × 26 = 23.4 inches.

PMP values for rainfall durations of 6, 12, 24, 48 hours are:

Duration (Hrs)	PMP (inches)
6 Hr	1 × 23.4 = 23.40
12 Hr	1.09 × 23.4 = 25.51
24 Hr	1.17 × 23.4 = 27.38
48 Hr	1.26 × 23.4 = 29.48

PMP values shown above are reduced by 17% to account for misalignment of basin and rainfall isohyetals.

The PMP for deriving PMF are therefore as following:

Duration (Hrs)	PMP (inches)
6	19.42
12	21.17
24	22.73
48	24.46

NEW JERSEY DAM SAFETY INSPECTION — SHEET NO. ___ OF ___
PMF DETERMINATION / EXPANSION DAM — JOB NO.
PROBABLE MAXIMUM PRECIP — BY ___ DATE ___

PMP Rainfall Distribution (Max 6 Hrs)

Distribution according to EC 1110-2-163.

Time (Hr)	Total 6 hr %	Total Rainfall Depth (inch)	Incremental Rainfall Depth (inch)
1	10	1.94	1.94
2	22	4.27	2.33
3	37	7.19	2.92
4	75	14.57	7.38
5	89	17.28	2.71
6	100	19.42	2.14

Direct Runoff Increment for Computing PMF

Time ending (Hr)	Incremental Design Rainfall (in)	Accumulative design Rainfall (in)	Direct Runoff Accumulative	Direct Runoff Incremental	Incremental loss
1	1.94	1.94	0.77	0.77	1.17
2	2.33	4.27	2.72	1.95	0.38
3	2.92	7.19	5.40	2.68	0.24
4	7.38	14.57	12.65	7.25	0.13
5	2.71	17.28	15.33	2.67	0.04 *
6	2.14	19.42	17.46	2.10	0.04 *

NC = 85 * USE MIN LOSS RATE OF .04"/hr for CALCULATION

HEC 1 - COMPUTATIONS

ECI-4 ENGINEERING CONSULTANTS, INC.

NEW JERSEY DAM SAFETY INSPECTION SHEET NO. 1 OF

FARRINGTON DAM JOB NO. 1209-001-1

INPUT TO HEC-1 BY KLB DATE 7-6-78

INPUT TO HEC-1

#	ELEV (FT)	Y2 VOLUME (AC-FT)	Y3 DISCHARGE (CFS)
1	50.0	0.	0.
(SPILLWAY CREST) 2	52.0	440.	3300.
3	52.5	600.	4500.
4	53.0	740.	6000.
(TOP OF DAM) 5	53.5	900.	7900.
6	54.0	1060.	9900.
7	55.0	1490.	14600.
8	56.0	1740.	20500.
9	58.0	2460.	30500.
10	60.0	3250.	51900.

NEW JERSEY DAM SAFETY INSPECTION — SHEET NO. 1 OF 1

PMF DERIVATION — FARRINGTON DAM — JOB NO. [illegible]

PMF — UHG — BY [illegible] DATE [illegible]

PMF · UHG / FARRINGTON DAM

I

Assume 25% of the area to be impervious

$\therefore\ I = 35$

t_c

$$t_c = 8.29\,(1 + 0.03 I)^{-1.28} \left(\frac{D.A.}{S}\right)^{0.28}$$

$I = 35$

$S = 8.59$ ft/mile

$D.A = 34.4$ Sq. mi

$$t_c = 8.29\,(1 + 0.03 \times 35)^{-1.28} \left(\frac{34.4}{8.59}\right)^{0.28}$$

$= 4.88$ hrs.

R

$$\frac{R}{t_c + R} = 0.65$$

$R = 1.86\,t_c$

$\therefore\ R = 1.86 \times 4.88 = 9.08$

Use $\boxed{t_c = 4.88 \text{ hrs } \& \ R = 9.08}$

```
******************************
HEC-1 VERSION DATED JAN 1973

******************************

                          DAM SAFTEY INSPECTION - NEW JERSEY
                                  FARRINGTON DAM
                                   PMF ROUTING

                                JOB SPECIFICATION
             NQ    NHR   NMIN   IDAY    IHR   IMIN  METRC   IPLT   IPRT  NSTAN
             65      1      0      0      0      0      0      0      0      0
                                JOPER    NWT
                                    5      0


     **********          **********          **********          **********          **********

                            SUB-AREA RUNOFF COMPUTATION

                            INPUT CLARK COEFFICIENTS

             ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME
                 9       0       0       0       0       0       1

                                  HYDROGRAPH DATA
      IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
          0       0   34.40    0.00   34.40    0.00   0.000       0       0       0

                                   PRECIP DATA
                            NP   STORM     DAJ     DAK
                             6    0.00    0.00    0.00
                                  PRECIP PATTERN
     0.77      1.95      2.68      7.25      2.67      2.10

                                    LOSS DATA
      STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
       0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00

                                UNIT HYDROGRAPH DATA
                        TC=   4.88     R=   9.08     NTA=   0

                                  RECESSION DATA
                   STRTQ=     0.00    QRCSN=     0.00    RTIOR= 1.00

      UNIT HYDROGRAPH 51 END-OF-PERIOD ORDINATES, LAG=    4.67 HOURS, CP= 0.38  VOL= 0.99
     151.      565.     1121.     1607.     1830.     1765.     1580.     1415.     1268.     1135.
    1017.      911.      815.      730.      654.      586.      524.      470.      421.      377.
     337.      302.      270.      242.      217.      194.      174.      156.      139.      125.
     112.      100.       89.       80.       72.       64.       57.       51.       46.       41.
      37.       33.       29.       26.       23.       21.       19.       17.       15.       13.
      12.

                                END-OF-PERIOD FLOW
                          TIME    RAIN    EXCS     COMP Q
                             1    0.77    0.77       116.
                             2    1.95    1.95       731.
                             3    2.68    2.68      2373.
```

4	7.25	7.25	6041.
5	2.67	2.67	12055.
6	2.10	2.10	19195.
7	0.00	0.00	25399.
8	0.00	0.00	28824.
9	0.00	0.00	29036.
10	0.00	0.00	27162.
11	0.00	0.00	24590.
12	0.00	0.00	22023.
13	0.00	0.00	19724.
14	0.00	0.00	17665.
15	0.00	0.00	15821.
16	0.00	0.00	14170.
17	0.00	0.00	12691.
18	0.00	0.00	11366.
19	0.00	0.00	10179.
20	0.00	0.00	9117.
21	0.00	0.00	8165.
22	0.00	0.00	7313.
23	0.00	0.00	6549.
24	0.00	0.00	5866.
25	0.00	0.00	5253.
26	0.00	0.00	4705.
27	0.00	0.00	4214.
28	0.00	0.00	3774.
29	0.00	0.00	3380.
30	0.00	0.00	3027.
31	0.00	0.00	2711.
32	0.00	0.00	2428.
33	0.00	0.00	2174.
34	0.00	0.00	1947.
35	0.00	0.00	1744.
36	0.00	0.00	1562.
37	0.00	0.00	1399.
38	0.00	0.00	1253.
39	0.00	0.00	1122.
40	0.00	0.00	1005.
41	0.00	0.00	900.
42	0.00	0.00	806.
43	0.00	0.00	722.
44	0.00	0.00	646.
45	0.00	0.00	579.
46	0.00	0.00	518.
47	0.00	0.00	464.
48	0.00	0.00	416.
49	0.00	0.00	372.
50	0.00	0.00	333.
51	0.00	0.00	298.
52	0.00	0.00	259.
53	0.00	0.00	210.
54	0.00	0.00	158.
55	0.00	0.00	62.
56	0.00	0.00	25.
57	0.00	0.00	0.
58	0.00	0.00	0.
59	0.00	0.00	0.
60	0.00	0.00	0.
61	0.00	0.00	0.
62	0.00	0.00	0.
63	0.00	0.00	0.
64	0.00	0.00	0.

```
                    65   0.00   0.00        0.

                   SUM  17.42  17.42   384663.

              PEAK   6-HOUR  24-HOUR  72-HOUR   TOTAL VOLUME
     CFS    29036.   26172.   14463.    5917.        384664.
  INCHES              7.07    15.64    17.33          17.33
   AC-FT             12984.   28703.   31806.         31806.


**********     **********     **********     **********     **********

                           HYDROGRAPH ROUTING

              ROUTE PMF HYDROGRAPH THRU FARRINGTON DAM

         ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME
             9       1       0       0       2       0       1
                              ROUTING DATA
                 QLOSS   CLOSS     AVG    IRES   ISAME
                     0   0.000    0.00       1       0

         NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA
             0       0       0   0.000   0.000   0.000     -1.

STORAGE=     0.    440.    600.    740.    900.   1060.   1490.   1740.   2460.   3250.
OUTFLOW=     0.   3300.   4500.   6000.   7900.   9900.  14600.  20500.  30500.  51900.
```

TIME	EOP STOR	AVG IN	EOP OUT
1	15.	116.	116.
2	34.	424.	262.
3	116.	1552.	873.
4	326.	4207.	2450.
5	729.	9048.	5891.
6	1272.	15625.	12224.
7	1754.	22297.	20704.
8	2091.	27111.	25377.
9	2277.	28930.	27968.
10	2284.	28099.	28063.
11	2169.	25876.	26468.
12	2003.	23307.	24162.
13	1831.	20874.	21764.
14	1684.	18695.	19181.
15	1582.	16743.	16774.
16	1507.	14995.	15018.
17	1423.	13430.	13875.
18	1318.	12028.	12726.
19	1207.	10773.	11510.
20	1101.	9648.	10352.
21	1006.	8641.	9229.
22	925.	7739.	8214.
23	854.	6931.	7359.
24	790.	6207.	6601.
25	732.	5559.	5921.
26	678.	4979.	5343.
27	628.	4459.	4801.
28	580.	3994.	4350.
29	531.	3577.	3984.
30	482.	3203.	3615.

31	434.	2869.	3262.
32	391.	2569.	2934.
33	351.	2301.	2655.
34	315.	2061.	2363.
35	282.	1846.	2118.
36	253.	1653.	1898.
37	226.	1480.	1700.
38	203.	1326.	1523.
39	181.	1187.	1364.
40	162.	1063.	1222.
41	145.	952.	1094.
42	130.	853.	980.
43	117.	764.	678.
44	104.	684.	786.
45	93.	613.	704.
46	84.	549.	630.
47	75.	491.	565.
48	67.	440.	506.
49	60.	394.	453.
50	54.	353.	405.
51	48.	316.	363.
52	43.	279.	323.
53	37.	234.	261.
54	31.	184.	235.
55	23.	110.	176.
56	15.	43.	113.
57	8.	12.	66.
58	4.	0.	34.
59	2.	0.	18.
60	1.	0.	9.
61	0.	0.	5.
62	0.	0.	2.
63	0.	0.	1.
64	0.	0.	0.
65	0.	0.	0.
SUM			384852.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	28063.	25634.	14328.	5920.	384852.
INCHES		6.93	15.49	17.34	17.34
AC-FT		12717.	28434.	31822.	31822.

RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	9	29036.	26172.	14463.	5917.	34.40
ROUTED TO	9	28063.	25634.	14328.	5920.	34.40

AD-A058 880   HARRIS ECI ASSOCIATES WOODBRIDGE NJ   F/G 13/2
NATIONAL DAM SAFETY PROGRAM. FARRINGTON DAM (NJ00383), RARITAN --ETC(U)
JUL 78 R GERSHOWITZ   DACW61-78-C-0100

UNCLASSIFIED   NL

2 OF 2
ADA
058880

END
DATE
FILMED
11-78
DDC

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                    DAM SAFTEY INSPECTION - NEW JERSEY
                            FARRINGTON DAM
                         ONE HALF PMF ROUTING

                          JOB SPECIFICATION
          NQ   NHR  NMIN  IDAY   IHR  IMIN METRC  IPLT  IPRT NSTAN
          65     1     0     0     0     0     0     0     4     0
                             JOPER   NWT
                                 5     0


     **********      **********      **********      **********      **********

                     SUB-AREA RUNOFF COMPUTATION

             INPUT CLARK COEFFICIENTS AND THEN MULTIPLY BY 0.5

           ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME
               9       0       0       0       0       0       1

                            HYDROGRAPH DATA
   IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
       0       0   34.40    0.00   34.40    0.00   0.500       0       0       0

                               LOSS DATA
  STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
   0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00

                         UNIT HYDROGRAPH DATA
                  TC=  4.86      R=  9.08     NTA=  0

                             RECESSION DATA
            STRTQ=    0.00    QRCSN=    0.00    RTIOR= 1.00

                          END-OF-PERIOD FLOW
                   TIME   RAIN   EXCS     COMP Q

                   SUM  17.42  17.42   584663.


     **********      **********      **********      **********      **********

                          HYDROGRAPH ROUTING

            ROUTE ONE HALF OF PMF HYDROGRAPH THRU FARRINGTON DAM

          ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME
              9       1       0       0       0       0       1
                              ROUTING DATA
                  QLOSS   CLOSS     AVG    IRES   ISAME
                    0.0   0.000    0.00       1       0
```

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                         NSTPS  NSTDL    LAG  AMSKK      X    TSK  STORA
                             0      0      0  0.000  0.000  0.000    -1.

STORAGE=       0.     440.     600.     740.     900.    1060.    1490.    1740.    2460.    3250.
OUTFLOW=       0.    3300.    4500.    6000.    7900.    9900.   14600.   20500.   30500.   51900.


    **********      **********      **********      **********      **********
```

RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	9	14518.	13066.	7231.	2958.	34.40
ROUTED TO	9	13849.	12668.	7158.	2960.	34.40

```
*****************************
HEC-1 VERSION DATED JAN 1973

*****************************

                    DAM SAFTEY INSPECTION - NEW JERSEY
                            FARRINGTON DAM
                              PMF ROUTING

                          JOB SPECIFICATION
  NQ   NHR  NMIN  IDAY   IHR  IMIN METRC  IPLT  IPRT NSTAN
  65     1     0     0     0     0     0     0     4     0
                   JOPER       NWT
                       5         0


 **********    **********    **********    **********    **********

                    SUB-AREA RUNOFF COMPUTATION

          INPUT CLARK COEFFICIENTS AND THEN MULTIPLY BY 0..

        ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME
            9       0       0       0       0       0       1

                            HYDROGRAPH DATA
 IHYDG   IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO  ISNOW  ISAME  LOCAL
     0      0   34.40    0.00   34.40    0.00   0.220      0      0      0

                               LOSS DATA
 STRKR  DLTKR  RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL  ALSMX  RTIMP
  0.00   0.00   0.00    0.00    0.00    0.00    0.00    0.00   0.00   0.00

                         UNIT HYDROGRAPH DATA
                  TC=  4.88     R=  9.08     NTA=  0

                            RECESSION DATA
          STRTQ=     0.00    QRCSN=     0.00    RTIOR= 1.00

                          END-OF-PERIOD FLOW
                   TIME   RAIN    EXCS    COMP Q

                    SUM  17.42   17.42   384663.


 **********    **********    **********    **********    **********

                         HYDROGRAPH ROUTING

           ROUTE ONE HALF OF PMF HYDROGRAPH THRU FARRINGTON DAM

        ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME
            9       1       0       0       0       0       1
                             ROUTING DATA
              QLOSS   CLOSS     AVG    IRES   ISAME
                0.0   0.000    0.00       1       0
```

```
                         NSTPS  NSTDL    LAG  AMSKK      X    TSK  STORA
                             0      0      0  0.000  0.000  0.000    -1.
 STORAGE=       0.     440.     600.     740.     900.    1060.    1490.    1740.    2460.    3250.
 OUTFLOW=       0.    3300.    4500.    6000.    7900.    9900.   14600.   20500.   30500.   51900.

       **********     **********     **********     **********     **********
```

RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	9	6387.	5758.	3182.	1301.	34.40
ROUTED TO	9	6008.	5429.	3149.	1302.	34.40

a) DISCHARGE VS. HEAD

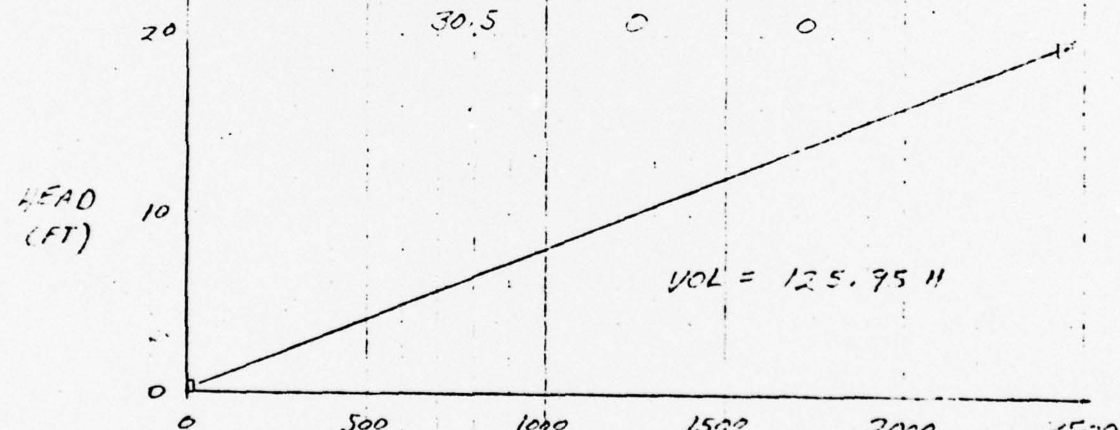
$Q = 12.47 \sqrt{h}$

(REFER TO MRS' NOTES)

b) STORAGE VS. HEAD

ASSUME A STRAIGHT LINE RELATIONSHIP FROM NORMAL WATER SURFACE VOLUME TO ZERO VOLUME AT ZERO HEAD

	ELEV (FT)	HEAD (FT)	STORAGE (AC·FT)
NWS	50	19.5	2456
	30.5	0	0



c) INFLOW; DRAINAGE AREA = 34.4 SQ. MI.

INFLOW = 2 CFS/SQ. MI X 34.4 SQ. MI. = 68.8 CFS

d) RESERVOIR EVACUATION TIME WITH CONSTANT INFLOW

[illegible] RESERVOIR CANNOT BE [illegible] UNDER THE ASSUMPTION OF [illegible]

c) RESERVOIR EVACUATION TIME WITH ZERO INFLOW

EVACUATION TIME WITH ZERO INFLOW [illegible]

([illegible] COMPUTER [illegible]) = [illegible]5 [illegible]

RESERVOIR EVACUATION
DAM CONTROL [illegible]

SHEET NO. 23.
JOB NO. [illegible]
BY [illegible] DATE [illegible]

HEAD (FT)	VOLUME (AC-FT)	TOTAL DISCHARGE (CFS)	INFLOW (CFS)	AVAILABLE DISCHARGE (CFS)	EVACUATION TIME (HR)
19.5					
	188.92	54.08	68.8	—	—
18.0					
	188.92	51.87	68.8	—	—
16.5					
	188.92	49.57	68.8	—	—
15.0					
	188.92	47.15	68.8	—	—
13.5					
	188.92	44.60	68.8	—	—
12.0					
	188.92	41.89	68.8	—	—
10.5					
	188.92	39.00	68.8	—	—
9.0					
	188.92	35.87	68.8	—	—
7.5					
	188.92	32.45	68.8	—	—
6.0					
	188.92	28.62	68.8	—	—
4.5					
	188.92	24.19	68.8	—	—
3.0					
	188.92	18.74	68.8	—	—
1.5					
	188.92	10.82	68.8	—	—
0.0					
TOTALS	2456.	—	—	—	—

FARRINGTON DAM CANNOT BE EVACUATED UNDER
THE ASSUMPTION OF 2 CFS/SQ. MI

RESERVOIR EVACUATION [illegible]

JOB NO. [illegible]

BY [illegible] DATE [illegible]

HEAD (FT)	VOLUME (AC-FT)	TOTAL DISCHARGE (CFS)	EVACUATION TIME (HR)
19.5			
	188.92	54.09	42.27
18.0			
	188.92	51.87	44.07
16.5			
	188.92	49.57	46.12
15.0			
	188.92	47.15	48.48
13.5			
	188.92	44.60	51.25
12.0			
	188.92	41.87	54.57
10.5			
	188.92	39.00	58.61
9.0			
	188.92	35.87	63.73
7.5			
	188.92	32.45	70.44
6.0			
	188.92	28.62	79.87
4.5			
	188.92	24.19	94.50
3.0			
	188.92	18.74	121.98
1.5			
	188.92	10.87	211.27
0.0			
TOTALS	2456.	—	987.16

RESERVOIR EVACUATION TIME WITH PIPE

FARRINGTON DAM — SHEET NO. 3

RESERVOIR EVACUATION — JOB NO. [illegible]

WITH CONSTANT INFLOW — BY [illegible] DATE [illegible]

HEAD (FT)	VOLUME (AC-FT)	TOTAL DISCHARGE (CFS)	INFLOW (CFS)	AVAILABLE DISCHARGE (CFS)	EVACUATION TIME (HR)
19.5					
	188.92	54.08	68.8	—	—
18.0					
	188.92	51.87	68.8	—	—
16.5					
	188.92	49.57	68.8	—	—
15.0					
	188.92	47.15	68.8	—	—
13.5					
	188.92	44.60	68.8	—	—
12.0					
	188.92	41.89	68.8	—	—
10.5					
	188.92	39.00	68.8	—	—
9.0					
	188.92	35.87	68.8	—	—
7.5					
	188.92	32.45	68.8	—	—
6.0					
	188.92	28.62	68.8	—	—
4.5					
	188.92	24.19	68.8	—	—
3.0					
	188.92	18.74	68.8	—	—
1.5					
	188.92	10.82	68.8	—	—
0.0					
TOTALS	2456.	—			

FARRINGTON DAM CANNOT BE EVACUATED UNDER THE ASSUMPTION OF 2 CFS/SQ. MI

FARRINGTON DAM — SHEET NO. 4 OF

RESERVOIR EVACUATION — JOB NO. 1209-[illegible]-1

WITH ZERO INFLOW — BY KLB — DATE 2/18-

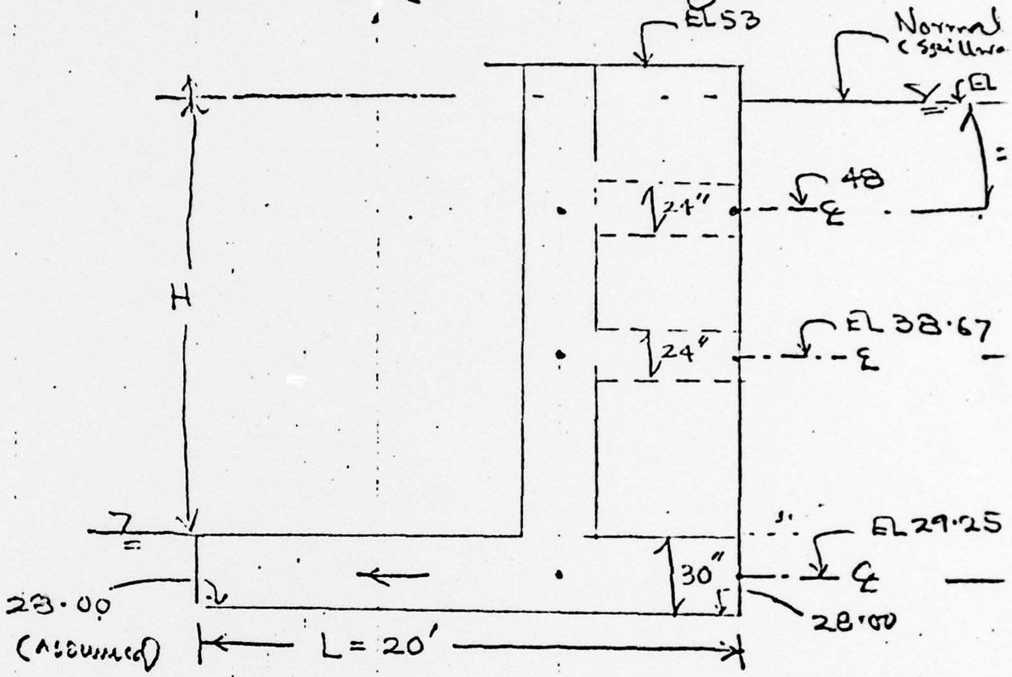
HEAD (FT)	VOLUME (AC-FT)	TOTAL DISCHARGE (CFS)	EVACUATION TIME (HR)
19.5			
	188.92	54.09	42.27
18.0			
	188.92	51.87	44.07
16.5			
	188.92	49.57	46.12
15.0			
	188.92	47.15	48.48
13.5			
	188.92	44.60	51.25
12.0			
	188.92	41.87	54.57
10.5			
	188.92	39.00	58.61
9.0			
	188.92	35.87	63.73
7.5			
	188.92	32.45	70.44
6.0			
	188.92	28.62	79.87
4.5			
	188.92	24.17	94.50
3.0			
	188.92	18.74	121.98
1.5			
	188.92	10.82	211.27
0.0			
TOTALS	2456.	—	987.16

RESERVOIR EVACUATION TIME WITH ZERO [illegible]

FARRINGTON DAM

Outlet Works :-

1. Dimensions (from drawing)



Determination of Outlet CAPACITY

Assumptions:

1. All the gates are fully open
2. Tailwater depth is just at the top the pipe at the tail. end
3. Rating curve is to be determin for elv. from 50 to 60.

Solution :

For simplicity assume flow only through the 30" pipe

For cast iron $\epsilon = 0.00085$

$$\therefore \frac{\epsilon}{D} = \frac{0.00085}{2.5} = 0.00034$$

$$\Rightarrow f = 0.0155$$

Assume $K_e = 0.9$

$$\therefore H = K_e \frac{V^2}{2g} + f \frac{L}{D} \cdot \frac{V^2}{2g} + \frac{V^2}{2g}$$

$$= \left[K_e + 1 + \frac{fL}{D}\right] \frac{V^2}{2g} = \left[1.9 + \frac{.0155 \times 20}{2.5}\right] \frac{V^2}{2g}$$

$$= 2.024 \frac{V^2}{2g} = 2.024 \frac{Q^2}{2gA^2}$$

$$= \frac{2.024 \times Q^2}{64.4 \times .785 \times 2.5^2} = 0.00641\, Q^2$$

$$\therefore Q = \sqrt{\frac{H}{.00641}} = \underline{\underline{12.49 \sqrt{H}}}$$

At normal pool level, $H = 50 - 28 - 2.5 = 19.5$ ft

$$\therefore V = \frac{12.49\sqrt{19.5}}{.785 \times 2.5^2} = 11.24 \text{ ft/sec}$$

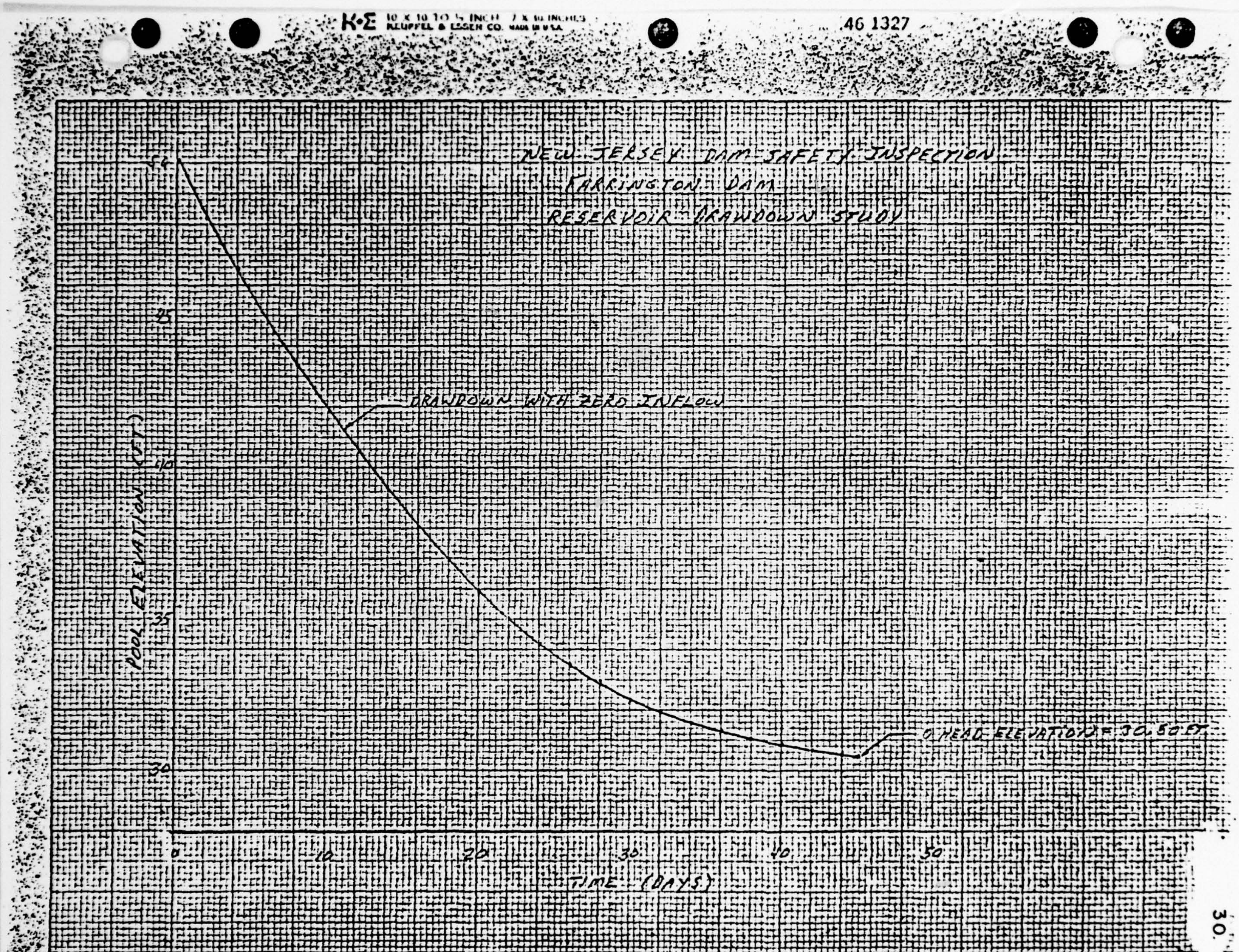
$$R = 11.24 \times 2.5 \times 10^5 = 2.81 \times 10^6$$ O.K Complete turb.

OUTLET CAPACITY BY [illegible]

Water surface elev. behind dam	H feet	$Q = 12.49\sqrt{H}$ cfs
50	13.5	55
51	20.5	57
52	21.5	58
53	22.5	59
54	23.5	61
55	24.5	62
56	25.5	63
57	26.5	64
58	27.5	66
59	28.5	67
60	29.5	68

Top of dam el 53

Assume the dam will be raised



K·E 10 X 10 TO ½ INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 1327
NEW JERSEY DAM SAFETY INSPECTION
KARRINGTON DAM
RESERVOIR DRAWDOWN STUDY
DRAWDOWN WITH ZERO INFLOW
0 HEAD ELEVATION = 30.50 FT.
POOL ELEVATION (FT)
50
45
40
35
30
0
10
20
30
40
50
TIME (DAYS)

FLOOD ROUTING STUDY
****

FARRINGTON DAM RESERVOIR DRAWDOWN STUDY (DA = 34.4 SQ. MI.)

1.0000 UNREGULATED DIVERSION CONDUIT AT ELEV 30.50 FT

MAXIMUM OPERATION LEVEL AT ELEV 50.00 FT (FROM OPERATI
MINIMUM OPERATION LEVEL AT ELEV 30.50 FT

ROUTING STARTS AT ELEV 50.00 FT, ENDS AT ELEV 30.50 FT

TIME		AVG.INFLOW	RESERVOIR EL	MAIN SPILLWAY DISCHARGE	OVERFLOW SPILLWAY DISCHARGE	Outlet DISCHARGE
DAY	HR	CFS	FT	CFS	CFS	CFS
0	0		50.00			
		0.				
0	12		49.54	0.	0.	55.
		0.				
1	0		49.09	0.	0.	54.
		0.				
1	12		48.64	0.	0.	53.
		0.				
2	0		48.20	0.	0.	53.
		0.				
2	12		47.76	0.	0.	52.
		0.				
3	0		47.33	0.	0.	51.
		0.				
3	12		46.91	0.	0.	51.
		0.				
4	0		46.49	0.	0.	50.
		0.				
4	12		46.08	0.	0.	49.
		0.				
5	0		45.67	0.	0.	49.
		0.				
5	12		45.28	0.	0.	48.
		0.				
6	0		44.88	0.	0.	47.
		0.				
6	12		44.49	0.	0.	47.
		0.				
7	0		44.11	0.	0.	46.
		0.				
7	12		43.73	0.	0.	46.
		0.				
8	0		43.36	0.	0.	45.
		0.				
8	12		42.99	0.	0.	44.

FLOOD ROUTING STUDY
****

TIME DAY	HR	AVG. INFLOW CFS	RESERVOIR EL FT	MAIN SPILLWAY DISCHARGE CFS	OVERFLOW SPILLWAY DISCHARGE CFS	Outlet DISCHARGE CFS
9	0	0.	42.63	0.	0.	44.
9	12	0.	42.28	0.	0.	43.
10	0	0.	41.92	0.	0.	42.
10	12	0.	41.58	0.	0.	42.
11	0	0.	41.24	0.	0.	41.
11	12	0.	40.90	0.	0.	40.
12	0	0.	40.57	0.	0.	40.
12	12	0.	40.25	0.	0.	39.
13	0	0.	39.93	0.	0.	38.
13	12	0.	39.62	0.	0.	38.
14	0	0.	39.30	0.	0.	38.
14	12	0.	39.00	0.	0.	37.
15	0	0.	38.69	0.	0.	37.
15	12	0.	38.39	0.	0.	36.
16	0	0.	38.09	0.	0.	36.
16	12	0.	37.80	0.	0.	35.
17	0	0.	37.52	0.	0.	34.
17	12	0.	37.24	0.	0.	34.
18	0	0.	36.96	0.	0.	33.
18	12	0.	36.70	0.	0.	32.
19	0	0.	36.43	0.	0.	31.
19	12	0.	36.18	0.	0.	31.
20	0	0.	35.93	0.	0.	30.

FLOOD ROUTING STUDY

****

TIME DAY	TIME HR	AVG. INFLOW CFS	RESERVOIR EL FT	MAIN SPILLWAY DISCHARGE CFS	OVERFLOW SPILLWAY DISCHARGE CFS	Outlet DISCHARGE CFS
		0.				
20	12		35.69	0.	0.	29.
		0.				
21	0		35.45	0.	0.	28.
		0.				
21	12		35.22	0.	0.	27.
		0.				
22	0		35.00	0.	0.	27.
		0.				
22	12		34.79	0.	0.	26.
		0.				
23	0		34.58	0.	0.	25.
		0.				
23	12		34.38	0.	0.	24.
		0.				
24	0		34.18	0.	0.	23.
		0.				
24	12		34.00	0.	0.	22.
		0.				
25	0		33.82	0.	0.	22.
		0.				
25	12		33.64	0.	0.	21.
		0.				
26	0		33.47	0.	0.	20.
		0.				
26	12		33.31	0.	0.	19.
		0.				
27	0		33.16	0.	0.	18.
		0.				
27	12		33.01	0.	0.	18.
		0.				
28	0		32.87	0.	0.	17.
		0.				
28	12		32.73	0.	0.	16.
		0.				
29	0		32.60	0.	0.	16.
		0.				
29	12		32.47	0.	0.	15.
		0.				
30	0		32.35	0.	0.	14.
		0.				
30	12		32.24	0.	0.	14.
		0.				
31	0		32.13	0.	0.	13.
		0.				
31	12		32.02	0.	0.	12.

FLOOD ROUTING STUDY
****

TIME		AVG. INFLOW	RESERVOIR EL	MAIN SPILLWAY DISCHARGE	OVERFLOW SPILLWAY DISCHARGE	Outlet DISCHARGE
DAY	HR	CFS	FT	CFS	CFS	CFS
32	0	0.	31.92	0.	0.	12.
32	12	0.	31.83	0.	0.	11.
33	0	0.	31.74	0.	0.	11.
33	12	0.	31.65	0.	0.	10.
34	0	0.	31.57	0.	0.	10.
34	12	0.	31.49	0.	0.	9.
35	0	0.	31.41	0.	0.	9.
35	12	0.	31.34	0.	0.	9.
36	0	0.	31.27	0.	0.	8.
36	12	0.	31.21	0.	0.	8.
37	0	0.	31.14	0.	0.	7.
37	12	0.	31.08	0.	0.	7.
38	0	0.	31.03	0.	0.	7.
38	12	0.	30.97	0.	0.	6.
39	0	0.	30.92	0.	0.	6.
39	12	0.	30.88	0.	0.	6.
40	0	0.	30.83	0.	0.	5.
40	12	0.	30.79	0.	0.	5.
41	0	0.	30.74	0.	0.	5.
41	12	0.	30.70	0.	0.	5.
42	0	0.	30.67	0.	0.	4.
42	12	0.	30.63	0.	0.	4.
43	0	0.	30.60	0.	0.	4.

FLOOD ROUTING STUDY

****

TIME		AVG.INFLOW	RESERVOIR EL	MAIN SPILLWAY DISCHARGE	OVERFLOW SPILLWAY DISCHARGE	Outlet DISCHARGE
DAY	HR	CFS	FT	CFS	CFS	CFS
		0.				
43	12		30.57	0.	0.	4.
		0.				
44	0		30.54	0.	0.	4.
		0.				
44	12		30.51	0.	0.	3.

****

RESERVOIR ELEVATION WENT UNDER MINIMUM WATERSURFACE ELEVATION
AFTER 44 DAYS AND 12 HOURS.

TOTAL INFLOW VOLUME	0.	ACFT
TOTAL DISCHARGE VOLUME	2449.	ACFT
MAXIMUM WATER SURFACE ELEVATION	50.00	FT
MAXIMUM DISCHARGE THRU DIVERSION CONDUIT	55.	CFS
MAXIMUM TOTAL INFLOW	0.	CFS
MAXIMUM TOTAL DISCHARGE	55.	CFS

APPENDIX E

SUMMARY OF STABILITY CALCULATIONS

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT: FARRINGTON DAM
STABILITY ANALYSIS - SUMMARY
COMPUTED BY: TJM CHECKED BY:
SHEET NO. 1 OF
JOB NO. 10-924-0
DATE 6/20/78

① CASE	② CONDITIONS		LOCATION ③ OF RESULTANT (FEET LEFT OF HEEL)	$\frac{\Sigma H}{\Sigma V}$	STRESS (PSI)		RESISTANCE TO SLIDING SHEAR-FRICTION
					HEAL	TOE	
IA	ORIGINAL	SECTION	17.73	.897	* 0 (58.2)	35.09	7.47
	HEADWATER	ELEV. @ 52					
IB	TAILWATER	ELEV. @ 33	16.91	.826	* 0 (69.4)	31.99	8.78
IIA	REPAIRED	SECTION	17.35	.878	* 0 (63.4)	34.50	8.06
	HEADWATER	ELEV @ 52					
IIB	TAIL WATER	ELEV @ 33	16.61	.775	* 0 (73.5)	32.17	9.31
IIIA	REPAIRED	SECTION	15.46	.775	* 0 (89.2)	26.41	11.07
	HEADWATER	ELEV. @ 50					
IIIB	TAIL WATER	ELEV. @ 27.5	14.80	.712	* 0 (98.2)	26.12	12.17
IVA	REPAIRED	SECTION	23.77	1.043	—	—	—
	HEADWATER	ELEV. @ 50	(OUTSIDE BASE)				
	TAIL WATER	ELEV. @ 27.5	(OUTSIDE BASE)				
IVB	2' OF	ICE	22.43	.958	—	—	—

* PER CENT OF DAM BASE IN COMPRESSION

① ALL "A" CASES INCLUDE 100% OF THE UPLIFT FORCES; ALL "B" CASES INCLUDE A REDUCTION IN UPLIFT FORCES DUE TO A SEEPAGE PATH

② FOR ALL CASES THE SOIL IS ASSUMED AT ELEV 31 ON THE UPSTREAM FACE OF THE DAM, AND AT ELEV 25 ON THE DOWNSTREAM FACE

③ THE MIDDLE THIRD OF THE DAM BASE LIES BETWEEN 7.33 AND 14.67 FEET TO LEFT (DOWNSTREAM) OF THE HEEL.